Lecture-Free Teaching

A Learning Partnership Between Science Educators and Their Students

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Dedication

To my husband, Stephen, and my two sons, Justin and Tyler, for their help and encouragement and, most of all, for being proud of me.

To my sister, Suzie, whose meticulous grammar and spelling kept me in good writing form during our daily e-mail exchanges.

To my sister-in-law, Debbie, who is writing her first novel and with whom I shared the challenge and exhilaration of a first book.

To my friend Deb, with whom I have shared animated conversations about science pedagogy during more than a decade of early morning bicycle rides, hikes, and cross-country skiing.

To my friend Anja, a trusted colleague, whose perspective from a different discipline provided insightful critiques of chapter drafts.

To colleagues and administrators at the University of Maine at Presque Isle, who encouraged me to take risks by exploring new teaching methods.

To each of my students—past, present, and future—whose feedback makes possible a true partnership of learning.

About the Author

Bonnie Wood grew up in Northern Virginia and first made her way to New England to attend Wellesley College in Massachusetts. After graduate school at Cornell University Medical College in New York City, two years in rural Montana teaching at a college outreach program on an Indian reservation, and a postdoctoral fellowship at the University of California at Davis, she settled in Northern Maine with her husband and two then-young sons. She has lived and worked in Presque Isle since 1979 and joined the full-time faculty at the University of Maine at Presque Isle in 1989.

Chapter 3

The Chronology of Course Design

Step 1 Consider the unique situation of the course you are preparing to teach.

Step 2 Determine the learning goals for the course.

Step 3 Create formative and summative assessments that provide feedback about the learning goals to both you and your students.

Step 4 Choose a teaching strategy that accomplishes the learning goals, responds flexibly to feedback from the assessments, and maintains coherence in the course.

Step 5 Develop in-class activities and homework assignments that achieve the learning goals, include formative assessments, and support the teaching strategy.

Step 6 Decide on a grading system for the semester.

Step 7 Assemble a topic schedule, with clearly indicated dates of in-class and laboratory activities, tests, and due dates for homework assignments.

Step 8 Use the course textbook and your previous lecture notes to create content outlines of topics and important terms you want students to know and understand.

Step 9 Compose a detailed course syllabus that describes features in Steps 1 through 8 and emphasizes the learning partnership between the students and you.

Step 10 Organize the topic schedule, syllabus, content outlines, in-class and laboratory activity worksheets, and formative assessments in a loose-leaf binder called *The Coursepack* that students will bring to each class meeting.

Step 11 On the first day of class, construct heterogeneous cooperative learning teams of four or five students.

Step 12 Use class time to answer student-generated questions and to lead activities and laboratory exercises that contribute to concept comprehension.

Step 13 Enjoy the unpredictable! Keep your mind and eyes open for new teaching techniques and activities that augment the cohesiveness of your course, support your learning goals, and stimulate a dialogue between you and your students.

Many books and articles guided my journey to Lecture-Free Teaching. Other books, discovered late in my reform process, demonstrate how the authors of those publications and I uncovered similar flaws in the traditional pedagogy and traveled different routes to transform our teaching, yet ended with solutions that share many characteristics (Fink 2003; McManus 2005; Wiggins and McTighe 2006). The books are affirming in their parallels to my chronology of course design, but at the same time the authors offer differences that may be helpful to some readers. Fink's and McManus's intended audience is college instructors, whereas the primary audience for Wiggins and McTighe is K–12 teachers. But my 13 steps for course design, as well as theirs, can be adapted to teaching in a wide range of disciplines and grades.

Step 1: Consider the unique situation of the course you are preparing to teach.

Whether you are planning changes in a class you have previously taught or designing new curricula, there are always conditions you cannot alter. In *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses*, Fink (2003) lists six situational factors to consider when planning a course.

The first situational factor is "Specific Context of the Teaching/Learning Situation." This category includes the number of students enrolled in the class; whether the course is for high school students in a particular grade or is an introductory, upper-level, or graduate course at a college or university; the length and frequency of the class meetings; the time of day and days of the week for class meetings; whether the classroom is a large lecture hall, a smaller classroom, a laboratory, or a seminar room; and the type and arrangement of seats and tables within that room.

Each condition can either enhance or detract from your ability to engage your students effectively. For example, enrollment numbers affect how many cooperative learning teams I build on the first day of class and how many students compose each team (Step 11). If the course is introductory, I consider that students will vary in their preparation for the course; if the course has prerequisites, I consider materials the students are expected to know. The length and frequency of class meetings affect the types of formative assessments and activities that I plan (Steps 3 and 5) to ensure that students can comfortably complete the tasks during class, with time for reflection and closure. Early morning classes and those that meet on Friday afternoons are undesirable for college students; different criteria apply for secondary school schedules. Type and size of the classroom and seating arrangement often are factors over which the educator has little control, but these variables can present an opportunity for creative use of space.

A hallmark of Lecture-Free Teaching is flexibility, and I try to be adaptable when responding to the factors mentioned. However, as I gain experience and confidence teaching outside the lecture mode, I become more adept at persuading colleagues and administrators that changes in the length and

frequency of my class meetings, as well as the arrangement of the classroom seats, enhance student learning. If we ever build a new classroom building, I will lobby for flexible seating to facilitate communication among students working in cooperative learning groups. But factors that cannot be changed will always exist and must be considered when designing a course.

Fink next describes "Expectations of External Groups," a factor particularly relevant to secondary school science educators who are constrained by district and state curriculum standards and lists of required content. At the college level an institution may dictate course or curriculum learning expectations, as might a professional accreditation organization. The catalog description of the course, often written by several educators who teach the same course, must be taken into account. When designing my courses, I consider how to meet these expectations in creative ways with my lecture-free pedagogy, remembering that science content can be delivered by a variety of methods.

The third situational factor is the "Nature of the Subject." A science course typically combines learning factual content with acquiring physical skills (such as using a microscope). Science is dynamic, lending itself to the exploration of changes and controversies. Such characteristics can be used to a science educator's advantage in a lecture-free format. I use the laboratory component to help students understand and apply the facts. Similarly, changes and controversies inherent in scientific disciplines can be shaped into discussions, debates, case studies, and other methods of reinforcing the content.

The fourth factor involves "Characteristics of the Learners," which include the current life situations of the students; the personal or professional goals they have for the course and their reasons for enrolling; their prior experiences, knowledge, skills, and attitudes about the subject; and their learning styles. This situational factor is challenging for me because of the heterogeneity of learners at my institution. I strive to present a course that is rigorous but at the same time accessible to students with poor preparation and study skills. Many of the undergraduates I teach are older than the traditional college student, and they often have considerable family and work responsibilities. Some students live on campus, and others commute long distances each day. Negative attitudes about required science and mathematics courses abound. Students may have been told they have a particular learning style or "don't test well," making them resistant or lacking in confidence when confronting certain types of teaching or assessment techniques. Accommodating dissimilar students can be challenging, but the variety inherent in Lecture-Free Teaching improves my chances of creating an appropriate learning environment for all. Construction of learning teams on the first day of class (Step 11) randomly groups students of differing abilities and interests and engages them in cooperative teaching and learning that potentially benefits all of them.

The fifth factor, "Characteristics of the Teacher," is probably the category most familiar to us as we design our courses, but at the same time it is the most difficult to change. We should contemplate our familiarity with and attitude toward the subject; whether the subject is within or outside our comfort zone; and our beliefs, values, strengths, and weaknesses as teachers and learners. All

of these characteristics vary widely among teachers, of course, but they also can be different for a single educator depending on the course he or she is designing. Each time I plan a course for the upcoming semester, I re-evaluate my personal characteristics related to this course. As my experience teaching a course increases, I sometimes recognize there is more to a subject than I originally appreciated. For the past two decades I have taught an undergraduate course in genetics, which is such a rapidly changing field that, in some ways, I feel less confident about my knowledge now than I did a few years ago. This creates new challenges when designing and preparing for this course.

Finally, Fink discusses the "Special Pedagogical Challenge." By this he means the special situation that challenges both students and teacher to create a meaningful and successful learning experience. An example would be the fact that my introductory science courses are primarily taken by students who are required to complete two science courses to graduate. They may believe they have no interest in the subject, and they also may lack confidence in their ability to do well. This is where creative use of Lecture-Free Teaching can help engage a reluctant student and reduce his or her anxiety.

Keep in mind that even if you teach several sections of the same course at the same school during the same semester, the situational factors can vary among those sections and necessitate changes in how you design and teach each section. We have all had instances where the morning section of a class runs smoothly and is enjoyable to teach, but the afternoon session leaves you feeling frustrated and incompetent. It is easy to blame this on a couple of less-than-cooperative students in the class, but paying attention to differences in other situational factors can lead to more successful and satisfying class meetings, saving you both time and emotional energy.

Step 2: Determine the learning goals for the course.

Too often as we plan a course, we begin by listing major content topics derived from the textbook's chapter titles—our goal is to cover those topics. When I first began teaching, senior faculty members who previously taught the courses handed me their syllabi, and I used their content topics as "my goals."

It wasn't until one summer when I sat down with a book called *The Course Syllabus: A Learning-Centered Approach* (Grunert 1997), now in its second edition (O'Brien, Millis, and Cohen 2008), that I articulated the true purpose of each of my courses, not only to myself but also to my students. My current learning-centered approach goes well beyond having students learn a body of content. Instead, my goals are more akin to those of a liberal education: I consider how to help my students change their views of the world significantly; how to foster an interest in the discipline that will continue beyond the date of the final exam; how to prepare students to make effective choices in the voting booth and become citizens of the world; and how to help them acquire thinking skills they can apply to other life endeavors. The box "Examples of Course

Learning Goals" lists course learning goals for three different types and levels of college courses.

For help identifying and ranking one's instructional goals, I recommend the Teaching Goals Inventory, a self-assessment devised by Angelo and Cross (1993). Comprehensive descriptions of how to formulate learning goals are provided in both *Understanding by Design* (Wiggins and McTighe 2006) and *Creating Significant Learning Experiences* (Fink 2003).

Examples of Course Learning Goals

For General Biology I (Biology 112)

1. Students will use written and oral communication, with terms associated with major topics in biology, to convey what they have learned, both to me and to their peers.
2. Students will apply knowledge to situations they have not yet experienced.
3. Students will use the scientific process to make observations, form hypotheses, design and conduct experiments, analyze results, and discuss conclusions.
4. Students will apply knowledge to make personal and ethical decisions.
5. Students will interact with peers in a cooperative learning team.

For Human Nutrition (Biology 300)

1. Students will apply nutrition facts to make practical dietary choices. They will demonstrate this skill individually and in collaboration with members of their cooperative learning teams.
2. Students will write a detailed and complete nutritional assessment (based on diet and physical activity) of their assigned service-learning partner.
3. Students will make effective dietary choices for themselves, their family, and their friends.
4. Students will practice scientific thinking skills that can be applied in other life endeavors.
5. Students will locate reliable sources of nutritional information and use them to make appropriate dietary decisions.

For Science Seminar (Biology/Environmental Studies 489)

1. Students will become familiar with the structure of professional science writing by reading examples of primary research papers, scientific dialogues, and case studies.
2. Using guidelines, students will choose topics appropriate for an original case study written in each of several case study styles.
3. By participating in weekly homework assignments, class discussions, and oral presentations, students will use the case study method to demonstrate the process of scientific inquiry.

4. Students will locate, read, and interpret scientific data during in-depth investigations of current scientific topics.
5. Students will logically defend or counter a position proposed by their chosen topics.
6. Students will follow a rubric to write a comprehensive and original case study that includes factual information from primary scientific literature, thought-provoking discussion questions, and teaching notes that describe how the case should be presented to a participating audience.
7. In an oral presentation, students will familiarize the audience with background information, present their case study stories, put participants into discussion groups to answer case questions, and facilitate discussion of the research questions.
8. Throughout the semester, students will offer constructive criticism of their classmates' case study ideas, manuscripts, and oral presentations.

Step 3: Create formative and summative assessments that provide feedback about the learning goals to both you and your students.

Partway through a decade of pedagogical reform, I realized that my assessments needed to better reflect my learning goals. I previously relied on summative assessments to measure and document student learning. I promptly returned graded tests and assigned papers and gave students time during class to ask questions about them, but there was no real opportunity or incentive for them to correct their errors or misconceptions. I observed many students taking a quick glance at their grade without bothering to read the comments and corrections I had painstakingly written in the margins.

I originally anticipated completing the circle of my pedagogical reform by modifying my summative assessments, but after reviewing the extensive assessment literature, I realized I could not use summative assessments effectively without first introducing formative assessments, during which students practice the skills needed to achieve the learning goals for each course. Students come to class with prior knowledge and possible misconceptions that affect their interpretations of new knowledge. In-class formative assessments, usually ungraded and often completed within a cooperative learning team, can dispel misconceptions and contribute to new, more accurate learning. Formative assessments provide information throughout the teaching and learning process to both my students and me so that I can adjust my instruction in ways that help students correct misunderstandings before they attempt a test or assignment on which they will be graded. This collaboration reinforces the learning partnership and is both a goal and a consequence of Lecture-Free Teaching.

A Daily Formative Assessment: The Murkiest Point

This formative assessment occurs at the end of every class meeting. As students depart, they hand me a small paper on which they have written their name and at least one point from the day's class that they found either confusing or interesting. To have his or her attendance recorded, a comment or question about the day's class must be submitted. I receive timely information about the effectiveness of my teaching and whether or not activities were useful, confusing, or interesting. At the beginning of the next class I respond to the "murkies." This assessment requires no teacher preparation, minimal class time, and a few minutes to review. With large class enrollment, a work-study student can record attendance and organize the questions. If used correctly, "murkies" provide valuable feedback to both students and educator, strengthening their partnership of learning.

I suggest that formative assessments be a part of every class meeting and take a variety of forms. Some assessments require almost no preparation and very little time to administer daily, such as the Murkiest Point (see above), or weekly, such as Genetics Problem Sets (see below). More elaborate assessments are effectively embedded in an in-class or homework activity designed to teach a content topic, such as Inheritance of ABO Blood Typing in Humans (Appendix C-1).

Excellent resources exist for easily locating a variety of appropriate assessments. A book for educators representing all disciplines is *Classroom Assessment Techniques: A Handbook for College Teachers* (Angelo and Cross 1993). *College Science Teachers Guide to Assessment* (Lord, French, and Crow 2009) is useful for both the educational researcher and the classroom educator and covers a variety of topics, including validation of assessment survey instruments, assessment of learning outcomes, forms of assessment, how-to assessment practices, and tips to enhance assessment in the college science classroom. A series of books with detailed instructions for formative assessment probes is designed for K–12 science educators, but can be adapted for use in postsecondary classrooms (Keeley 2008; Keeley, Eberle, and Dorsey 2008; Keeley, Eberle, and Farrin 2005; Keeley, Eberle, and Tugel 2007; Keeley and Tugel 2009).

A Weekly Formative Assessment: Genetics Problem Sets

Problem solving is an essential skill for mastery of genetics. Most genetics textbooks include a large collection of end-of-chapter problem sets, making it easy for an instructor to choose ones representative of the style and scope of questions for an upcoming test. Weekly problem sets assigned for homework can be an effective formative

assessment; the challenge is to motivate the students to devote sufficient individual effort while encouraging them to work in study groups. Grading problem sets not only contradicts the purpose of formative assessments, but also requires a lot of time for the teacher. On the other hand, if homework is purely voluntary, few students are disciplined enough to complete it each week. My compromise is to assign problems at the end of each week (based on that week's content) and have them due at the first class meeting the following week. The beginning of that class is reserved for answering questions about specific homework problems. Immediately after answering questions, I collect the problem sets and grade them for completeness only. After class I post solutions on Blackboard. This assessment gives students and me prompt feedback on concept comprehension, provides me a measure of whether students are investing sufficient time on problem solving, and serves as an opportunity to clear up misconceptions about the previous week's content.

To ensure that students devote appropriate effort to ungraded assessments, you must respond promptly to the results with meaningful feedback. If questions on the Murkiest Point are not answered at the beginning of the next class, if weekly problem sets are not reviewed and collected, if in-class exercises are not discussed to reveal confusion, then students will not take these activities seriously. Each time you teach, ask yourself what you would like your students to be able to do at the end of the day's instruction, and then design an assessment that will determine if they can do it. As you discover whether your students have achieved the day's learning goals, your students will become aware of their own misconceptions and move down the path of independent learning. Involve your students in the phases of your teaching reform by explaining changes you have made or will make in response to assessment results.

The best summative assessments require a demonstration of skills and knowledge practiced during formative assessments by asking students to apply them to novel situations. At the end of Appendix C-2 is an appropriate test question based on an inquiry-based laboratory. Graded tests, papers, and group assignments should not only quantify student learning but also enhance that learning. Occasionally, a student will tell me excitedly that while taking a test, he or she thought about a concept in a different way and finally understood it. When that occurs, I know that I have stumbled on an effective evaluation of significant learning. I strive to have all of my assessments accomplish this.

Step 4: Choose a teaching strategy that accomplishes the learning goals, responds flexibly to feedback from the assessments, and maintains coherence in the course.

When I began incorporating active learning into my teaching repertoire, I gave too little consideration to a teaching strategy. One stated goal in my sabbatical application was to "incorporate at least one active learning exercise into each of my lectures." The result was a sometimes disjointed class meeting comprising activities that were relevant to content topics but not always providing a smooth transition from one topic to the next. As I gained experience in Lecture-Free Teaching, I created teaching strategies that supported the learning goals by encouraging students to prepare before each class meeting. One of my primary responsibilities is to demonstrate connectedness among content topics and in-class activities.

Although my teaching strategies depend somewhat on specific learning goals for a particular course, I generally provide detailed content outlines to guide students through their textbook reading and note-taking before each class meeting (Step 8). Rather than using class time for lecturing, I begin by answering questions e-mailed to me about the textbook reading, as well as the Murkiest Point questions submitted at the end of the previous class (Chapter 7). Next come in-class activities designed to expose misconceptions stemming from prior knowledge or textbook readings. These activities allow me not only to correct students' misunderstandings before it is too late but also to give students opportunities to practice skills they will need for summative assessments. Lecture-free does not mean that I never stand in front of the class and share factual information. I often give what could be described as mini-lectures, but these are in direct response to student questions or confusion, rather than being short presentations I plan in advance to follow a prescribed schedule during a class meeting.

Students taking notes before each class on an outline of content topics and important terms effectively substitutes for my giving a lecture. Students' notes are derived from reading their textbooks and ensure that they are informed of content I expect them to know, just as a lecture would. Although a student must be organized and disciplined to accomplish this reading and note-taking in advance, I experience greater success with this strategy than with anticipating that my lecture will inspire students to do the reading afterward, as promoted by others (Lord 2007). Occasionally reviewing notes students have (or have not) made on their outlines gives me a tangible method to guide better study methods. Reinforcing learning during class is a more efficient use of time and also motivates students to attend class because they know I will not use class time to review what they could simply read on their own. My job is to convince students that preparing for and participating in class leads to better comprehension of concepts and, ultimately, saves them time (Chapter 6).

A consistent teaching strategy for all of my courses is cooperative learning (Chapter 12) that begins in the first 15 minutes of the first class meeting of the semester (Chapter 10). Many studies validate the effectiveness of cooperative learning (Lord 2001), and I have fully embraced this method. A detailed discussion of cooperative learning takes place in Part III of this book.

I avoid predictability in the structure of class meetings. An element of surprise keeps both my students and me engaged; curiosity as students anticipate an upcoming class is an incentive for regular attendance. My teaching is an amalgamation of a variety of instructional strategies created and perfected by other educators (Chapters 10–16). Although I admire each of these strategies, they become tedious if used exclusively week after week. I combine them in ways that create variety while challenging me to maintain coherence within and between class meetings. An examination of sample topic schedules in Appendix A-1–6 demonstrates that some topics are introduced by a laboratory exercise, whereas others conclude with one; some content lends itself to using a case study; sometimes learning teams work together for the entire class meeting; sometimes individuals give presentations; and sometimes formative assessments dominate the class period.

Possible connections are always on my mind as I read journals such as *The American Biology Teacher* and *Journal of College Science Teaching*. When I see a good idea for a specific activity or a laboratory exercise with potential for one of my courses, my first consideration is determining how well the activity will integrate into the class. I strive to use activities that reinforce and expand on previous experiences so that the early activities become the base on which students build comprehension of more complex topics.

The course syllabus that I distribute in General Biology I (Appendix A-8) describes several writing assignments, including a scientific report of a laboratory investigation. Because I make liberal use of case studies (Chapter 15), the first class meeting is an ideal time to present this instructional strategy, while at the same time introducing students to cooperative learning within their newly formed teams (Chapters 10 and 12). During a recent semester I chose an introductory case study that not only is inherently interesting to students but also acquaints them with the scientific process and models the structure of their upcoming scientific reports.

"Cell Phone Use and Cancer: A Case Study to Explore the Scientific Method" (Parilla 2006) is among hundreds of case studies published by the State University of New York at Buffalo on the peer-reviewed website of the National Center for Case Study Teaching in Science. After volunteers assume roles of different characters and read the case aloud, I hand each learning team copies of five different news articles about research on cell phone use and cancer. Each team member reads at least one of the short articles and summarizes it for the team. The group discusses differences among the headlines of the five articles, analyzes the scientific methodology described, and compares results and conclusions. Based on these articles from the lay press, the learning team offers suggestions for improvement of the scientific study. At the end of the

exercise, I give students the original research article (Lönn et al. 2004) on which each of the shorter articles was based so they can compare information presented by the lay press with the publication by the scientists. Many students have never seen an article in the primary literature. For homework they read the article, and at the next class we review how the scientific process was followed and how the journal article models their own future scientific reports.

By the end of the first week of the course, students have experienced two components of my teaching strategy—cooperative learning and the case study—and have acquired skills and knowledge they will apply throughout the semester. Each time they begin an inquiry-based lab exercise or participate in a case study, this learning is reinforced.

Step 5: Develop in-class activities and homework assignments that achieve the learning goals, include formative assessments, and support the teaching strategy.

Years ago I decided that one of my goals was to develop my students' scientific reasoning skills, but I did not yet appreciate that my courses displayed a disconnect between teaching strategies and learning goals. After a series of a content-laden lectures, I created test questions that required students to apply factual information to solve novel problems. My students, not surprisingly, could not make the leap and performed poorly on these questions. I realized that my instructor-centered strategy encouraged memorization of facts, but my test questions asked students to apply those facts in new ways. Today I enjoy designing activities that allow students to simultaneously learn and understand content.

Journals are a great source of ideas for in-class and homework activities. Like many people, my husband and I subscribe to more periodicals than we have time to read. They accumulate, partially read, on the kitchen counter, the living room coffee table, and bedside tables until, during a break between semesters, I devote several days to intense reading and then recycle the ones I will never have a chance to read. But two journals that I read promptly and cover-to-cover are *The American Biology Teacher* and *Journal of College Science Teaching*. I make the time for these journals because I am fearful I will miss a suggestion I could use immediately. In those two publications I find ideas for in-class activities and homework assignments for nearly all of the courses I teach. A comprehensive list of science education journals is available on the National Center for Case Study Teaching in Science website, from the State University of New York at Buffalo. Journals for educators in agriculture, anthropology, biology, chemistry, dentistry, engineering, environmental studies, geography, geology, mathematics, nursing, pharmacy, physics, psychology, statistics, and veterinary medicine are described on the site.

Topical journals, along with books and online sources, provide appropriate ideas for every discipline and age group. Increasingly, I do not use an activity as originally presented by its author but rather adapt it to more closely

fit my learning goals. Often, after I lead an activity, I ask my students to suggest ways to improve it for the next time I teach the course. Sometimes an article inspires my own idea for a completely different learning activity, such as the new way in which I used "sock chromosomes," described below.

Genetics lends itself particularly well to learning by manipulating models. Over the years my students have used paper, popsicle sticks, pipe cleaners, Twizzlers, and beads on a string to represent chromosomes. Several different articles (Chinnici, Neth, and Sherman 2006; Oakley 1994; Stavroulakis 2005) suggest using socks to demonstrate mitosis, meiosis, and karyotyping, all of which I have done.

I recently took ingredients from those previously published articles to create my own recipe for an entirely new use of sock chromosomes. When I lead hands-on workshops, I begin the session just as I do the first class meeting of a semester: I randomly divide participants into cooperative learning teams of approximately four people, using one of my methods for accomplishing this while at the same time introducing students to content (Wood 2007, 2009). For a workshop at a national conference of biology educators, I wanted to challenge participants with something more than I would students on the first day of an introductory course. At a local discount store I bought numerous "homologous pairs" of socks (socks of the same size and style, but with different colors or patterns). As the workshop participants gathered, they passed around a large bag in which I had mixed all of the single socks. After each person had reached into the bag and selected one sock, I asked everyone to search the room until they located their "sister chromatid." After finding "her" (or him!), they would work together to find their "homologous pair," then form a tetrad by sitting together, and finally become a four-person learning team for the workshop session.

As I stressed in Step 4, activities should contribute to the cohesiveness of the curriculum. The instructor should also avoid too many different activities during one class meeting. When first using active learning, I feared that activities would conclude too quickly, leaving me with extra time during which I would be forced to lecture or (heaven forbid!) dismiss class early. Although I often have extra activities ready to go, I rarely use them and instead reserve time at the end of the class meeting for closure and reflection on the activity's connection with previous and future topics. My change to fewer, longer class meetings each week provides this important conclusion time because I do not spend time getting the class "warmed-up" on multiple days of the week (Chapter 8).

I always look for elements that tie the entire course together and that I can use to reinforce earlier material while building on the foundation. My goals are to connect all of the course strands during class meetings near the end of the semester and to create appropriate comprehensive questions for the final exam.

Step 6: Decide on a grading system for the semester.

A useful book called *Effective Grading: A Tool for Learning and Assessment* (Walvoord and Anderson 1998) includes several grading models. A commonality among them (including my own, which I describe later in this chapter) is that the grading system communicates the instructor's values and goals for the course.

To determine a course's grading system, I list all of the tests, assignments, and other factors that will contribute to the semester grade. Then I return to my previously determined learning goals (Step 2) to be sure everything listed reflects those goals. To assign points to each item, I consider the comparative value I place on each aspect of the course. Rather than starting with a specific number of course points to divide among the assessments, I allot points to each test or assignment, starting with the one that contributes the most (for example, 100 points for a comprehensive final exam or a major paper), and then assign fewer points to the others based on their relative contribution toward accomplishing the learning goals. Finally, I total the number of points for the list of assessments (Appendix B-1). The student receives a letter grade according to the percentage of total possible points earned.

The list of graded tests and assignments, along with their point distribution, is in the course syllabus. The relative number of points conveys to students the value I place on each category of assessment so they can determine the time and effort they should invest in each. Too often students spend an excessive amount of time on a task that does little to help them achieve the learning goals.

I believe a student who does well on a comprehensive final exam has acquired the skills and knowledge that I have assessed on earlier topic tests. If a student earns a solid C or better on the comprehensive final, I drop the lowest previous test score when calculating his or her course grade. The purpose is to motivate students to maintain their effort through the end of the semester. The policy gives students another chance to understand the material, this time with the perspective of an entire semester of learning. I generally wait until midterm (which immediately precedes the last day to withdraw from a course at my university) to announce this opportunity. The intentional delay deters students from slacking off for most of the semester, mistakenly thinking they can make it up at the end. Furthermore, I do not want to encourage students for whom there is no hope of passing to remain in the course after the withdrawal deadline because they believe they can somehow ace the final. I want them to realize that although the final exam represents a substantial component of the course grade, it is just one element; dropping a single low grade does not erase an entire semester of poor performance.

Once you draft a grading system, you need to confirm that it truly reflects how you value each component of the course. For example, you may want to be sure that a student who actively participates in class but has not achieved other learning goals will not inappropriately inflate his or her grade through vigorous class participation. Or perhaps you value participation so much that a participative student who would ordinarily get a D now gets a C. If student

performance on written, individual tests best reflects your learning goals, then the grading system must demonstrate this. If a final project is as important as the combined tests, then possible points for the final project should be equal to total test points.

My grading system is easily modified to include extra credit points by simply adding extra credit to an individual's earned points without adding points to the possible total points. For example, learning-team members may earn a few extra credit points during test review activities (Chapter 12). I occasionally offer extra credit points when students attend a relevant public lecture if they submit a short reflective essay about the experience. I maintain extra credit points as separate categories in the grade record, rather than adding on points to a particular test, because I want students to have accurate information about their performance on a test.

Avoid potential pitfalls when incorporating extra credit points by making certain you do not place too much relative value on them. Students should not be able to pass a course because they accumulated extra credit points. If I offer extra credit points for participating in an event outside of class time, some students complain that this is unfair because they have a schedule conflict. I point out to them that another student's extra credit points do not subtract points from their grade; they can use the time not spent on extra credit work to do better on the regular assignments.

I have no need to modify my grading system for penalties because the only official penalty I have is for late submission of work, for which I subtract one point (usually from 30 or 35 possible points) for each day an assignment is late. I emphasize this policy both in the syllabus and verbally, thereby avoiding subjective decisions about giving extensions. Students rarely request extra time to complete a paper or argue with me about it. They make their own decision about whether it is worth it to turn in something late—another lesson in assuming responsibility.

I never grade on the curve because this emphasizes competition among students and undermines my goal of cooperative learning. If many students perform poorly on a particular test, I look for flaws in questions and sometimes eliminate them from test grade calculations. If just a couple of students correctly answer a flawed question, I can add extra points to their grade. I announce to the class how I have done this, rather than using a curving formula.

Step 7: Assemble a topic schedule, with clearly indicated dates of in-class and laboratory activities, tests, and due dates for homework assignments.

As students enter the classroom on the first day of the semester, I hand them a topic schedule (notice that I do not call it a lecture schedule!). The topic schedule depends on elements I describe in Steps 1 through 6, so it is created after the completion of these steps. But since content outlines, the syllabus,

and coursepack organization depend on the topic schedule, construction of this latter element must precede Steps 8 through 10.

The layout of the topic schedule affects students' interpretations of their responsibilities during the semester. I needed several years of trial and error before finalizing a template that eliminates confusion. I try to limit my topic schedules to the front and back of an 8½- × 11-inch paper, with the first half of the semester on one side and the second half on the other. The order of column headings on my table format is important: Listing homework assignments in the far left column underscores that students should complete the homework before the scheduled class, which may be the reverse of the order to which they are accustomed. An example of a typical topic schedule for General Biology I is in Appendix A-1, followed by examples of topic schedules for five other courses (Appendixes A-2, A-3, A-4, A-5, and A-6).

Although I avoid exceeding the length of a double-sided sheet of paper, I include as much detail as I can to reduce verbal reminders about upcoming assignments. The responsibility is shifted to the students when they adopt the habit of checking the topic schedule several times each week. My obligation is to stay on schedule as much as possible and to promptly notify students of changes. My previously described policy (Step 6) of deducting one point for each day an assignment is late also contributes to students' taking more responsibility and is an effective method for receiving assignments in a timely fashion.

My university uses Blackboard, an online course-management system that permits easy communication with students enrolled in a course and provides links to a variety of course information. Although I post topic schedules on Blackboard as well as on my web page, I distribute a hard copy (three-hole punched so that it can be inserted in the coursepack) on the first day of class to better explain how the course is organized and what I expect from the students. The topic schedule is most useful if kept in the front of the coursepack, which contains content outlines and worksheets (Step 10).

Step 8: Use the course textbook and your previous lecture notes to create content outlines of topics and important terms you want students to know and understand.

Content outlines ensure that a course includes necessary and appropriate factual material and that students are informed about the sections of textbook chapters that I consider most important. In other words, content outlines substitute for a lecture: Many of my content outlines are derived from past lecture notes, so they include exactly the same topics about which I would lecture. Student note-taking on outlines *before* class replaces student note-taking *during* lectures. By guiding students through the chapters of the text, content outlines free class time for in-class activities that help students better comprehend and apply scientific information and uncover misconceptions or confusion based on prior knowledge or from reading the textbook.

On the first day of class I explain to students how to use the content outlines provided in their coursepacks. I also explain this in the syllabus for each course in the section "How to Succeed" (Appendix A-8).

An example of a content outline is included in Appendix A-7. I format content outlines with four spaces between each term and concept to allow adequate room for note-taking as students read the assigned textbook chapter. This sample outline relates to other examples in this chapter: Students take notes on Outline 10: Genetics to prepare for Week 9 class meetings indicated on the sample topic schedule for General Biology I (Appendix A-1); these meetings include participation in the in-class activity Inheritance of ABO Blood Typing in Humans (Appendix C-1).

Placing outlines with related in-class activities in a coursepack supports my teaching strategy goal of maintaining coherence (Step 4). As indicated in the General Biology I topic schedule, the sample Genetics outline follows two previous weeks of learning about DNA replication and cell reproduction. The first part of Outline 10 links these earlier topics to new terms that students need to understand and use during their study of genetics. The part of the outline about genotype and phenotype prepares students to participate in the in-class activity on ABO blood types. Several weeks later in the semester, students review and apply what they learned about these blood groups to understand immunology and ABO/Rh blood typing in humans.

Step 9: Compose a detailed course syllabus that describes features in Steps 1 through 8 and emphasizes the learning partnership between the students and you.

As discussed in Step 2, I did not truly understand the purpose and value of a well-designed syllabus until I read *The Course Syllabus: A Learning-Centered Approach,* now in its second edition (O'Brien, Millis, and Cohen 2008). As the authors explain, a comprehensive learning-centered syllabus not only describes what the instructor will cover but also is an important resource to support learning and intellectual development. Composing such a document requires substantial thought and analysis; a syllabus evolves each time you teach a course to a different set of learners. The process of articulating learning goals, assessments, teaching strategies, activities, grading practices, and content helps you develop and teach a better course.

The syllabus often is the first communication between you and your students. When carefully conceived, it can demonstrate effectively your beliefs about education, your values concerning the content and structure of the course, and your expectations for students and what they can expect from you. A well-written syllabus can minimize misunderstandings throughout the semester. An example of a course syllabus for General Biology I is in Appendix A-8.

Traditionally, faculty use the first day of class solely to distribute and review the syllabus. Before the semester begins, I alert students via e-mail that they will begin learning content on the first day of class and that this

meeting will last for the full class period (frequently almost three hours for my combined lecture/laboratory courses). Although I distribute both the topic schedule and the syllabus as students enter the classroom on that first day, I immediately engage students in an activity (Step 11) that not only introduces them to some course content but also sends the message that attendance is important at all class meetings and that our time together will be used for learning that cannot occur outside class.

Although I may discuss key sections of the syllabus, I mention several times that the first assignment is to read the syllabus carefully. This is also listed as homework on the corresponding topic schedule. Those students who comply will find a surprise extra credit opportunity on the final page of the syllabus. At the beginning of the second class I announce how many students took advantage of this, thereby reinforcing the importance of students' taking responsibility for their own learning.

My syllabus is generally six single-spaced pages (in addition to two pages of topic schedule), and all eight pages are designed to be a resource for the entire semester. The syllabus provides not only practical information about the course but also more general information (such as learning goals, teaching techniques, assignments, and the grading system), always emphasizing the students' responsibility for their own learning and the ongoing partnership between the students and me.

Step 10: Organize the topic schedule, syllabus, content outlines, in-class and laboratory activity worksheets, and formative assessments in a loose-leaf binder called *The Coursepack* that students will bring to each class meeting.

I have developed coursepacks for each course I teach and modify them as an important part of my preparation for an upcoming semester. Students buy coursepacks in the campus bookstore as one of their required texts. This arrangement not only saves my department money by eliminating the need to copy handouts, but I also believe that purchasing even a modestly priced coursepack increases students' commitment to the course. In addition, with all course materials in their possession from the first week of the semester, students can plan ahead and know exactly what they will miss if absent.

Most important, with a coursepack students can view the structure of the entire semester. Demonstrating coherence is a critical part of my teaching strategy (Step 4), and over the years I have become more skilled at choosing appropriate activities so that individual class meetings not only have a theme and make smooth transitions between activities but also allow students to experience connections among the content topics. Having all of the semester's course elements in chronological order in a single loose-leaf notebook underscores these links.

Each time I lead a workshop on Lecture-Free Teaching, someone suggests that rather than requiring students to purchase hard copies, I post each week's

coursepack material online. Although it is true that assembling coursepacks makes my preparation for an upcoming semester more intense, I believe there is a distinct advantage to having all of the course materials in a binder that is brought to every class meeting. I number coursepack pages consecutively, making it convenient to ask students to turn to a particular page during class or to refer to previous or future exercises to emphasize connections among content topics. Students own their coursepacks, and if a student loses his or her coursepack, she or he must buy another copy—another way of encouraging students to take responsibility for their own learning. And, of course, I never need to worry that they forgot to print needed materials for an in-class activity from the online source. The meat of every coursepack is the content outlines (Step 8) on which students take notes while reading an assigned chapter.

Step 11: On the first day of class, construct heterogeneous cooperative learning teams of four or five students.

The first day of class is, in many ways, the most important class meeting of the semester. Investing time and effort to plan an interesting, well-organized day can create a positive classroom climate that lasts the entire semester. The first class is your opportunity to set the stage for constructive interpersonal relations among the students and between you and your students.

Goals for my first class meeting include having students

- understand the benefits of my Lecture-Free Teaching methods,
- experience how the course is structured and what is expected of them,
- learn some course content,
- begin to feel comfortable with their classmates and to develop a rapport with me, and
- understand their responsibility for the success of the course.

My method for building heterogeneous learning teams initiates work toward all of these goals within the first 15 minutes of the semester. In Chapter 10, I describe how for each course I design a different organizational concept by which students form cooperative learning teams of four or five students with whom they will work on in-class and homework activities for the semester (Wood 2007, 2009).

Because of previous negative experiences, some students are reluctant to work in groups. Explaining to them, at the outset, the proven benefits of teamwork and also how I will monitor, evaluate, and assess contributions of team members (Chapter 12) starts them off with a more positive attitude about what may be an unfamiliar or uncomfortable learning tool. The theme of the team-building activity introduces factual content that is reiterated throughout the semester, so this exercise is much more than an icebreaker (Appendix C-4).

I believe in the power of words and that your choice of words affects listeners' or readers' perceptions and expectations of what you want to communicate. For years I talked to students about forming cooperative learning groups, an important instructional strategy first promoted in the 1980s (Johnson and Johnson 1989; Johnson, Johnson, and Smith 1991). Now I prefer the expression *learning teams* (Michaelsen, Knight, and Fink 2004). This term is meaningful to my many sports-minded students and describes a supportive interaction among students that ultimately benefits everyone.

Step 12: Use class time to answer student-generated questions and to lead activities and laboratory exercises that contribute to concept comprehension.

I invite students to communicate promptly with me about course content they do not fully understand. There are several different ways to accomplish this:

- E-mail me questions before 7:00 a.m. on the class day
- Write the Murkiest Point at the end of a class meeting (Murkiest Point box, p. 27)
- Call or visit me in my office
- Use the time-honored method of raising one's hand during class

The first thing I do at a class meeting is respond to "murkies" from the previous class, as well as to any questions I received via e-mail. In the syllabus I explain that if I receive no questions or requests for additional explanation of a topic, I assume everyone in the class understands both the previous and new material. I then proceed with the scheduled in-class activity or laboratory exercise. As I describe in Step 4, I sometimes give what could be described as mini-lectures, but these are in direct response to student questions or confusion.

During a semester I employ a variety of instructional strategies, described in detail in Part III of this book: inquiry-based laboratories resulting in scientific reports; writing by students; cooperative learning, including Peer Instruction, Problem-Based Learning, and test review sessions; Team-Based Learning; service-learning; case studies; and student-led teaching models. As discussed in Step 5, a plethora of classroom-tested activities for science students at all levels is available in journals, books, and online sources. I keep in mind that what I have the students do during class should increase their understanding and give them practice applying factual knowledge related to the day's topic. With Lecture-Free Teaching one cannot predict exactly how long a planned exercise will take, so I reserve time for clarification and closure at the end of every class.

Class time should be used for learning that students cannot accomplish alone outside the classroom. Students in Light's (2001) study reported that classes in which a professor simply repeats what they have just read or could easily read in a textbook are not a good use of their time. Similarly, Tobias

(1990) found that in-class activities, laboratory exercises, videos, and guest lectures will not be taken seriously by students unless test questions and homework assignments reflect these experiences.

Step 13: Enjoy the unpredictable! Keep your mind and eyes open for new teaching techniques and activities that augment the cohesiveness of your course, support your learning goals, and stimulate a dialogue between you and your students.

Although the unpredictability of leading a lecture-free class may be unsettling at first, I encourage you to embrace the energy that accompanies this pedagogy. Flexibility and responsiveness to what happens during each class meeting with each unique group of students are the keys to the success of my methods.

I began my teaching reform by gradually incorporating others' ideas about which I had read or heard. As I gained experience and confidence, I used more of my own ideas, and now I am sometimes surprised by my creativity. An everyday experience or conversation can suggest an ideal in-class activity or laboratory investigation. I am increasingly bold about trying something completely new, but afterward I ask students to reflect on what we have done and tell me whether it was helpful to them, if I should repeat it with future students, and their recommendations for improving the activity.

Honest feedback from students is vital. We ask our students to take risks in their learning, and we must do the same. My hopes are that as we develop rapport and mutual respect, students feel more like equal participants in the process and that we truly engage in the learning partnership referred to in the subtitle of this book.

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