In most disciplines, professors ask students to “read” without specifying what this operation means for their particular field. This chapter traces the path laid out in a cultural history class, where reading entails identifying the essential elements of a text.

Decoding the Reading of History: An Example of the Process

David Pace

There are few areas in which the differences in learning across academic disciplines are more visible than in that of reading. The instruction “read” has such a radically different meaning in the context of courses in physics, accounting, English, or history that we probably do students a disservice by even using the same word. This is a particularly difficult problem in history, where students often face hundreds of pages of reading and where several different forms of reading may be required in the same course. If college history teachers do not make some effort to teach the forms of reading necessary for their classes, it is likely that many students will be stopped at the beginning of the learning process.

Step 1. What Is the Bottleneck to Learning in This Class?

I began to grapple with this problem in the late 1980s and early 1990s (Pace, 1993) as my encounters with the scholarship in the field made me increasingly aware of the disciplinary nature of learning (see, for example, Brown, Collins, and Duguid, 1989; Tobias, 1992–1993). But I was only able to fully confront this challenge in the mid-1990s, when I set out to create from scratch a one hundred-student course on the history of ideas about the future for my university’s freshman topics program.

My goal was to create a level playing field in which students who had weak backgrounds in historical thinking would have the same chance to master the material in the course as those who had been “preeducated.” My previous experience as a teacher strongly suggested that I should focus a
great deal of attention on the problems students face with reading. The most obvious problem was that of selectivity. Students lacked criteria for deciding what was most essential in a text and what could be passed over. Storytelling is essential to historical writing, but students tended to give the details the same attention as the broad outline of the story. For years I had heard students complain that they had difficulty remembering everything they had read. I had told them to concentrate on what was important, but I now recognize that this process of identifying the most important aspects of a text was a more complex task than I had realized and that I needed to show my students just how I went about this process.

Thus, my students' difficulty in distinguishing between the essential and the nonessential elements in a text was a clear bottleneck to learning in my course. This posed a problem for a large percentage of my students, and students found it difficult to master the basic elements of the course without having mastered this bottleneck. Therefore, I decided that this should be one of the central features around which I would shape the early weeks of the course.

Step 2. How Does an Expert Do These Things?

Before I could help students learn the specific forms of reading required in history courses, I had to reconstruct what professional historians do when they read secondary sources. This is a more difficult step than might be imagined because the process is so automatic to a trained historian that it is apt to be invisible. In retrospect, I can see that the process would have been greatly aided if I had then had access to the literature on reading in history at both the secondary and college levels that was just beginning to appear, in particular the research of Wineburg, who has marvelously demonstrated the intertextuality that lies at the core of so much of historical reading (Wineburg, 2001; Perletti and others, 1994; Shemilt, 2000; Britt and others, 1994; McKeown and Beck, 1994). Lacking access to this literature at the time, I first tried introspection to get an idea of the steps that I, as a professional historian, take automatically when presented with a secondary source like those that my students struggle with. I also asked faculty members from history departments of my own and other universities just what they wanted students to do when they asked them to read particular passages.

From this, there emerged a series of steps by which expert historians organize a text as they read, separating what is essential from what is not:

They bring to the text a series of questions that need to be answered and add other questions as they arise from the process of reading.
They identify the central thesis and the subsidiary arguments that explain or qualify it.
They distinguish between these arguments and the evidence used to support them.
They commit to memory the central and the subsidiary arguments. They retain selected bits of evidence to help them understand the nature of the argument and ignore the rest.

This filtering process seems self-evident to professional historians, but it is different from that used in other disciplines, and it is foreign to many of those who take my courses. To students who read all the statements in a secondary source as existing on the same level, none of this architecture exists. They process the statement of the central thesis of a study in precisely the same manner as the least important piece of evidence, and the task of memorization is enormous. Even if they are capable of such prodigious acts of memory, they find that the mass of details is of little use in completing the basic tasks of the course.

**Step 3. How Can These Tasks Be Explicitly Modeled?**

Because the ability to discriminate between essential and nonessential elements of a historical narrative is crucial to success in my course, I have devoted a significant amount of energy to helping my students master this ability during the first week. On the first day of class, I tell the students that part of their job in college is to learn the specific forms of thinking that are needed in each field in which they take courses. Then I describe history as a storytelling discipline in which it is necessary to understand the point of the story, not to memorize all of the details. I let them know that they will need to be able to separate the broader story (or thesis) from the details that support it; remember the story (or thesis) using the examples to confirm that they understand the point; and forget most of the details, retaining only a few well-chosen examples to help them remember the story and to allow them to support the position if they need to. I show a passage from the assigned readings in a PowerPoint slide and then show the same passage again, but this time I have changed the font size of different phrases to indicate that for the purposes of our course, their importance determines their size (see Figure 2.1).

After a discussion of why I made these particular choices, I pledge that at no point in the course will they be asked a question that quizzes them on details such as name five prophets in the Old Testament. A similar exercise, involving collaborative learning teams, reinforces this learning in the second class period.

Because redundancy is an essential element in learning complex tasks, I placed a parallel description of this process on the course Web site. But I have also used the interactive potential of the Internet to model historical reading in a more dynamic manner. On a second Web page, a student can click on icons scattered across a passage from the week's readings and hear a recording of what was going through my mind as I read that part of the text. To give the listener a relatively unmediated experience of my reading
process, I intentionally recorded these comments without preparation or rehearsal and did not edit the hesitations and word choices. As I spoke, I was actually modeling several different aspects of historical reading, such as linking parts of this text to other texts or themes from the course. But the recording focused particularly on the process of establishing a hierarchy of importance in the text. To emphasize this point, I even indicated that, in the middle of an ancient Akkadian poem that had nothing to do with the issues in my course, I was going to skip to the end of that section without reading it all. (This and samples of other materials described in this chapter can be viewed at http://www.indiana.edu/~flp.)

Step 4. How Will Students Practice These Skills and Get Feedback?

Modeling the kinds of mental operations that are necessary for work in a discipline can be a crucial element in a systematic strategy for overcoming obstacles to student learning. But it is unlikely that these patterns of thinking will

Figure 2.1. Modeling Reading History Selectively

First overhead: A passage from the reading

“The Jewish apocalyptic genre emerged from the earlier prophetic tradition, but is distinct from it. The Jewish prophets of the eighth to the sixth centuries B.C.—Amos, Joel, Isaiah, Jeremiah, Ezekiel, and the others—functioned primarily as preachers, focusing on the people's transgressions and foretelling the Lord's renewed favor if they repented and further woes if they did not. The prophets were present minded and specific as they addressed a people beset by enemies and continually straying from the path of righteousness.”

Second overhead: The same paragraph with the importance of difference sections emphasized:

“The Jewish apocalyptic genre emerged from the earlier prophetic tradition, but is distinct from it. The Jewish prophets of the eighth to the sixth centuries B.C.—Amos, Joel, Isaiah, Jeremiah, Ezekiel, and the others—functioned primarily as preachers, focusing on the people's transgressions and foretelling the Lord's renewed favor if they repented and further woes if they did not. The prophets were present minded and specific as they addressed a people beset by enemies and continually straying from the path of righteousness.”
become part of students' cognitive repertoire unless they have opportunities to practice them and receive feedback. My course on the History of the Future provided this opportunity in two forms: in-class team exercises and online weekly assignments.

In the second class period, I reinforced the modeling of the previous meeting when I again gave the class another passage, but this time I asked them to decide in teams what parts are most and least important to remember and to articulate the principles that led to these judgments. The shared nature of this work not only forced students to make explicit the criteria that they use to establish a hierarchy of importance but also allowed me to provide them with extra feedback on how well they understood the process.

Ultimately, however, the students must learn to operate in the world of history on their own, and they need individual as well as group practice and feedback. Therefore, I have added to the course Web site weekly assignments modeled after Novak's Just-in-Time Teaching (Novak, Patterson, Gavrin, and Christian, 2004) that are targeted at specific operations that the students must master to succeed in the course. For example, in the first weekly Web assignment, students are given an additional passage from the readings and asked once again to specify one item from the text that they think they should not remember for the purposes of this course, to provide one item that they should remember, and to briefly explain both choices. In subsequent Web assignments, they are regularly asked to specify the central idea of a particular reading assignment, thus giving them more practice at distinguishing between essential statements of a thesis and supporting evidence.

These team and Web assignments serve to reinforce the basic patterns of historical reading that I have modeled in class, and they give the students feedback on their progress in this area. Thus, if students are at all engaged in the course, they should know well before the first exam whether their reading strategies are appropriate for this kind of course. At the same time, this work gives students an occasion to engage in some informal metacognitive explorations of how they used their minds in this and in other courses.

**Step 5. What Will Motivate the Students?**

This step of motivating students is absolutely crucial, and it needs to be considered carefully before the process of modeling, practice, and feedback begins. Students must be drawn willingly into this process of learning about learning, and it would be a serious error to assume that if we build a perfect pedagogical playing field, the students will automatically come along. They may need a special invitation.

Relatively few undergraduates conceive of their courses in terms of mastering different disciplinary ways of thinking, and they have to be shown that it is in their interest to spend time on this, rather than moving
directly to "what will be on the test." I couch the presentation of the Decoding the Disciplines process (see Chapter One) in terms of students getting the maximum return on the time that they invest in a course. I point out that many surveys suggest that the difference between students who do well and those who do not is often more the result of how they study than of how much they study. I make it clear that a real commitment of time and energy is necessary for success, but that if they are not working in a manner that is appropriate to the discipline they are studying, more work is not apt to yield a higher grade.

The structure of the Decoding the Disciplines model itself can also make a positive contribution to motivation. It moves the focus from large, potentially overwhelming challenges, such as writing an essay exam, to more discrete and manageable tasks, such as deciding what is essential to remember in a passage of assigned reading. Students receive meaningful feedback each week on well-defined actions, rather than global feedback a few times during the course. Their sense of mastery can increase as they move to ever more complex tasks, and the learning environment is transformed from a few giant leaps to a series of manageable steps.

In addition, I present myself consistently as someone who wishes them to succeed and who has gone to considerable lengths to make it possible for them to master this material, regardless of their level of previous preparation. I mention my own difficulties as a first-generation college student moving from a substandard high school to a demanding college, and I stress that I have tried to create a course in which any student who has met the admissions requirements of my university should be able to succeed if she or he is willing to put in the work. But at the same time I make it clear that I have high expectations for them, that whereas the individual steps may be smaller, I expect them to make a real commitment to the process and to climb as high as or higher than students in other history classes.

Finally, I have placed this process of mastering historical thinking within an aesthetically pleasing and intellectually exciting context. The in-class work on these operations is accompanied by PowerPoint presentations that give visual learners an experience of the history of the future through images ranging from medieval frescos of the Apocalypse to science fiction covers from the 1920s. The weekly assignments are therefore part of a rich course Web site that gives students an experience of texts and images that reinforces this learning.

Step 6. How Well Are Students Mastering These Learning Tasks?

One of the great virtues of the Decoding the Disciplines model is that it makes assessment of student learning much simpler. When instructors attempt to measure global and often fuzzy concepts such as critical thinking, it is difficult to pinpoint which students have mastered the skills and
which have not. In a history course, for example, a bad performance on an essay exam may be the result of a failure to master the grand concepts of the course or of an inability to operate on the much more basic level, such as knowing how to read in a manner appropriate to the discipline. Or a student may have mastered nine of ten essential skills, but the absence of the last one makes invisible the success that has been achieved.

The process of defining disciplinary operations brings precision to the process of assessment, and in most cases the mechanisms that give students an opportunity for practice and feedback can themselves provide useful information about where student learning is and is not occurring. This allows us to decide where to devote more of the precious class time to skills mastery and where that is less necessary.

As I have indicated earlier, in my course on the History of the Future, the team and Web exercises simultaneously help model basic operations, give the students practice at these operations, and serve to provide feedback. The results have been encouraging. Whereas in the past, a large number of my students in introductory courses remained unable to read secondary sources in a manner that is appropriate in a history course, now virtually the entire class demonstrates by the end of the first week that they can successfully discriminate the relative importance of different parts of the passage.

This exercise in prioritizing is not the end of the process because a number of other aspects of historical reading need to be taught later in the semester, and the basic patterns covered in the first week will need to be reinforced from time to time. But I can move forward in the knowledge that the great majority of the class will not be swamped in a sea of historical facts, all seemingly of equal importance.

It is also important to remember that this process does not—and in most cases should not—exclude more traditional methods of assessment. Students in my course write take-home essays in response to questions that I provide, just as they have always done in my classes. This provides them with an occasion to combine specific operations they have been learning in more complex tasks in a manner that more directly parallels the kinds of challenges they will be facing in later life. But now I can feel confident that if a student does badly, it is because he or she has not made a real commitment to the process, not because of a preexisting deficit of educational opportunity that my course is only compounding.

But what of content? In the case of the History of the Future course, what about changing patterns of thought, such as belief in the Apocalypse and secular progress, trust in technology and fear of nuclear devastation, the exclusion and inclusion of various groups in visions of the future, and all the other questions that arise when a historian looks at this material? What place has all of this content in a course that begins with step-by-step exercises in how to read history? I can slightly limit the effects of the time transferred from content to skills by being certain that the passages used in
these exercises are particularly important to an understanding of the material because these are the sections of the readings that students are most apt to remember. But class time is limited, and the time spent on such exercises must be subtracted from time previously devoted directly to studying historical developments.

These are serious concerns, but ultimately these potential objections assume a kind of fetishistic relationship to teaching, as if the important event is what words pass through my mouth, not what new ideas enter my students' brains. In fact, the only thing that really matters is what happens in the minds of students. If my students do not understand the basic language of history, my presentations are as pointless as if they were delivered in ancient Akkadian. Absolutely nothing real has been lost if the content that has been sacrificed was not being understood in the first place.

In the past, I was faced with a chilling choice between teaching to the small portion of the class that had already been preeducated in the craft of history or of lowering the level of instruction to a flat recitation of facts. I now feel that I have tools that can give me the ability to open the discussion to students who would otherwise never have access to the great banquet of knowledge and insight that contemporary historiography can offer them. If I can expand the number of students who can be invited to this banquet by even a few percentage points each semester, it is a small price to pay for a diversion of a small portion of the time I share with them.

References


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For three biology professors, visualizing molecular processes is central to thinking in their discipline. This chapter reports their attempts at getting students to make this same cognitive move and the results of their assessments.

Decoding Genetics and Molecular Biology: Sharing the Movies in Our Heads

Miriam Zolan, Susan Strome, Roger Innes

As classroom teachers in biology, we struggle with the proper balance of content versus process. We teach an information-rich science that is expanding exponentially. Yet, most faculty would agree that the average biology student has trouble understanding fundamental biological processes such as meiosis (the segregation of chromosomes into sperm and egg cells) and gene regulation (how genes are turned on and off). Because these processes are complex, we typically ask our students to learn many specific details about them, but simply learning the details does not necessarily lead to a true understanding of how a process works. Showing lots of pictures in class and explaining a process in great detail during a lecture does not seem to give students practice in the kinds of thinking we expect them to learn.

Partly because of these frustrations, several members of the biology faculty at Indiana University, including the three of us, have been investigating alternatives to standard lecture formats for teaching biology. We encountered the Decoding the Disciplines model (see Chapter One) as fellows in our university's Faculty Learning Community. Using this approach, we began by each defining a bottleneck that our students faced. Although the three of us defined our bottlenecks differently and came up with different solutions, in retrospect we were all trying to overcome a similar problem: how to get our students to move beyond the memorization of facts to a deeper understanding of biological processes.

The next step in the Decoding the Disciplines approach was to define the steps that we, as professional scientists, would use to overcome the
challenges that limit our students’ learning. This led to the realization that in response to the kinds of problems contained in all three bottlenecks, we usually develop a kind of dynamic movie or cartoon in our minds that organizes the information we currently have and helps us make a guess (hypothesis) about how the process might work. We also realized that we were not explicitly developing such model-building skills in our students and that this was an essential skill for making sense of the vast array of information we present to them.

To address this problem, each of us independently developed some form of hands-on modeling exercise (step 3 of Decoding the Disciplines) that required students to manipulate objects to illustrate a process. We found that it was not enough for us to demonstrate biological processes; we had to help students develop the dynamic cartoons we use in our minds. Furthermore, we learned that students could develop their skill at this kind of visualization using kinesthetic props (MacKinnon, 2003). Following this modeling step, we gave students ample opportunity to practice these skills, to receive feedback (step 4), and to use such opportunities as a tool for testing their own understanding of the process. We motivated our students through exercises that were kinesthetically appealing and gave them a sense of self-efficacy. Before setting the students loose on these exercises, we explicitly told them what we were trying to accomplish by having them create these models and how we hoped it would facilitate their learning (step 5). Finally, we assessed the results of these efforts regularly across the semester, often using Classroom Assessment Techniques (CATs) borrowed from Angelo and Cross (1993). Below, each of us describes our specific modeling exercise, and our assessment of its effectiveness.

**Problem-Based Learning in the Study of Mitosis and Meiosis (Zolan)**

As part of the introductory course for biology majors, I cover the cell divisions of mitosis and meiosis, with an emphasis on chromosome segregation. The bottleneck I addressed was that students do not have a clear understanding of mitosis and meiosis. They have encountered the terms in previous (high school) classes and do not really listen when they are supposed to be investigating them again. They also have trouble distinguishing between identical (sister chromatids) and similar chromosomes (homologs). The lack of a firm understanding of these processes makes it difficult for students when they later study genetics.

My traditional method of teaching mitosis and meiosis was to draw out the cell divisions in lecture, show how they are the basis for eukaryotic genetics, and then reinforce the descriptions with some demonstrations using pipe cleaner models. Unfortunately, this did not prove to be sufficient for my students to be able to visualize this dynamic process in the manner that I and other biologists do (MacKinnon, 2003). Therefore, I decided to flip my approach and use an inquiry-based learning strategy
wherein students would “invent” mitosis and meiosis by working with simple pipe cleaner models.

**Description of the First Class Session.** As the approximately 250 students in my course entered the classroom for the first lecture on this material, they picked up two red and two white pipe cleaners, each of which had a piece of blank tape attached. After I defined some terms for the students, they labeled one of the red “chromosomes” with a bead marker, representing an allele of the ABO blood group locus. I asked the class for the possible choices, and students eagerly volunteered because it was something they confidently knew. They then labeled one of their white pipe cleaners with an allele for an Rh factor gene, after a similar discussion of choices.

I then asked students whether their chromosome complement would make up a haploid or a diploid cell. After they correctly identified their chromosome complement as haploid, students then “mated” their two chromosomes with those of a neighbor to create a diploid cell. I talked about genotype and phenotype and then had partners work together to decide the genotype of their cell, whether it was heterozygous or homozygous for the two genes, and what the phenotypes of the cell were for these traits. As a class, we then built up genotype-phenotype charts for both genes and defined dominance and codominance.

Next, I asked students to discuss with their partners how to start with one of them holding all the chromosomes used so far and end with both of them having a complete chromosome set. I reminded them that they could use additional pipe cleaners. I told them to think about what mitosis does, what it needs, and how it might work. As students worked in pairs or small groups, I circulated among them and helped them get started. After students had worked together, I asked for volunteers to explain what they had done and helped students bring out the two important features: DNA replication and separation of sister chromatids into the two products of mitosis.

In the future, I will have undergraduate instructors circulate during the lessons, preventing students from using the size of a large class to avoid active participation in the exercise. Students might also be asked to sit with their own learning groups to minimize their anonymity.

When the students next met with their weekly learning groups, they were asked to repeat the process of mitosis (step 4 in the Decoding the Disciplines model), to draw chromosomes at different stages of the mitotic cell cycle, to use pipe cleaners to illustrate meiosis, and then to mate the resulting haploid products to create new diploid individuals.

**Assessment.** Before the lessons began, students took a multiple-choice pretest that asked them to classify four pictures as representative of particular phases of mitosis or meiosis. After the lessons, students were again asked to classify five similar pictures as particular phases of mitosis or meiosis. In this post-test, a fourth category, “does not represent a stage of normal mitosis or meiosis,” was added to the multiple-choice answers, and a fifth picture, which was not a possible stage of either process, was also added. Figure 3.1 shows the percentages of students correctly identifying
the pictures in the pretest and post-test and their scores on two of the same questions on the final exam seven weeks later. It is clear that more students were able to correctly identify the pictures in the post-test than in the pretest.

**My Evaluation of the Process.** This process was valuable because it turned a study of mitosis and meiosis on its head (by having students “invent” these processes rather than listening to a lecture about them) and allowed the students and me to see what they do and do not understand.

**Modeling Chromosomes and Genetic Processes (Strome)**

I teach a course in genetics to sophomore and junior-level students. Understanding how chromosomes and the genes that reside on them behave during mitosis and meiosis is at the heart of almost all concepts that we study in genetics. A bottleneck that I have faced over the years is the difficulty students have visualizing chromosomes, appreciating the distinction between similar and identical chromosomes (for example, homologs and sister chromatids), and predicting their segregation patterns during mitosis and meiosis. My goals were to develop easy-to-manipulate, three-dimensional
representations of chromosomes and genes and to have the students model their behavior during mitosis and meiosis and during other genetic events.

**Representing Chromosomes and Genes with Pipe Cleaners and Beads.** The first day of class, I used the “background knowledge probe” CAT (Angelo and Cross, 1993) to find out what students already knew about chromosomes. The students’ answers clearly showed that there was a lot of confusion about the definition of a chromosome and the distinction between homologs and sister chromatids. I explained that we would model chromosomes using pipe cleaners and model genes using beads. Pipe cleaners and beads allow visualization of which chromosomes are identical, which chromosomes are similar, and which chromosomes are completely different.

To convey what *identical, similar, and different* mean for chromosomes, I used the simple genetic system of the fruit fly. Fruit fly cells, with two each of only four different chromosomes, are easy to model with pipe cleaners: two blue, two yellow, two green, and two red pipe cleaners (Figure 3.2). Genes were represented as colored beads, which I strung on the pipe cleaners to represent either different genes (pairs of beads both the same pattern or shade of gray in the figure) or different forms of a particular gene (single pair of beads that are different shades in the figure). Students could see from the lineup of beads on the two red pipe cleaners that those “chromosomes” were similar (homologs) but not identical. For simplicity, I stripped off all but the purple and aqua beads, leaving those to mark and track the homologs during mitosis and meiosis. I used our pipe cleaners and beads to model the exact duplication of chromosomes, which is the first step in mitosis and meiosis. This created identical chromosomes (sister chromatids), as shown in Figure 3.2.

Students were then given their own sets of pipe cleaners and beads and asked to work together to model the different ways that chromosomes can align in preparation for cell division. Students discovered for themselves how different chromosome alignments lead to different outcomes during mitosis and meiosis.

We used pipe cleaners and beads throughout the semester to model a number of important concepts in genetics (see http://www.indiana.edu/~flp). An important component of all of our discussions was following up on our pipe cleaner and bead work by devising two-dimensional representations of chromosomes and genes for students’ notes. We usually used different-colored lines for different chromosomes and standard genetic symbols for different forms of a particular gene. We went back and forth frequently between drawings and pipe cleaners to help students consolidate what they had learned and to ensure that they understood the different representations. In the process, my students internalized the visualization processes that are automatic to biologists and necessary for understanding biology.

**Assessment.** To gauge students’ understanding of chromosomes and their ability to apply that understanding to new situations, I posed questions
Figure 3.2. Modeling Fruit Fly Chromosomes Using Pipe Cleaners and Beads

in class and asked students to work in groups of two or three and hold up their group answer as pipe cleaners and beads for the class to see. If one or only a few groups figured out the correct answer, they explained their answer to the rest of the class. This polling was informative because it showed me immediately what percentage of groups came up with correct arrangements of pipe cleaners and beads, and more important, it showed the ways in which some arrangements were incorrect. That enabled me to focus on each group's misconception(s).

I also used a CAT known as “Conceptest” (Ellis, Landis, and Meeker, n.d.) where I had students work together to solve chromosome-based problems and then asked them to vote for one of several answers. If a significant fraction of the class missed the problem, I asked them to resume discussion and then vote again. After the second round of discussion, I sometimes asked students with a firm grasp of the concept to explain their logic to those who were still confused.

One question on exam 1 tested the students’ ability to draw, organize, and correctly label meiotic chromosomes. Sixty-six percent of students answered this question correctly. Exams 2 and 3 each had a “chromosome basics” question as part of a bigger problem to solve. The percentage of
students who drew and labeled chromosomes correctly was 73 percent and 71 percent, respectively.

**My Evaluation.** I think that most students benefited from seeing me consistently use pipe cleaners and beads, either projected onto a screen by way of a document camera or held up as I circulated through the class. However, it turned out to be awkward to have the students use pipe cleaners and beads in class, in large part because the desktops in the class were too small to accommodate both notes and learning kits. Having students sit at tables would be preferred (Wood, 2003) because it would allow them to lay out and manipulate their chromosome sets while still being able to talk with each other and take notes. In fact, during office hours and when talking with students after class, we often used pipe cleaner models on a desk or tabletop. As students set up and worked through different scenarios, I was treated to a few “eureka” moments as students connected our pipe cleaner-and-bead exercises with their prior knowledge and with concepts presented in class. I will definitely continue to use pipe cleaners and beads, but in the future I will modify how I ask the students to work with them, perhaps by moving some of their hands-on pipe cleaner and bead work to the small-group discussion sessions that meet each week to work on problem sets.

**Using Our Bodies to Model Molecular Processes (Innes)**

I have been teaching molecular biology and genetics at the university level for the past thirteen years and during this time have been continually impressed by the disconnect between the ability of most students to learn long lists of “facts” (quite good) and their ability to use these facts to understand how a particular process works in space and time (very poor). For example, a process that I feel is central to molecular biology is how a gene is “turned on” at the right place and right time. This is a complex process that requires an understanding of protein structure and interactions among various proteins and between proteins and DNA. Although students readily learned the names of specific proteins and DNA sequences that are involved in this process, exam questions that moved beyond simple regurgitation of facts revealed that most students were failing to understand how the process actually worked. On discussing this bottleneck with a nonscientist colleague, I realized that part of my students’ difficulties might stem from their lack of practice with thinking of biological information in terms of animated processes. Perhaps my students were not routinely painting pictures in their minds that organized information in terms of a cartoon. I therefore developed an exercise that made such modeling an explicit part of the learning process, with two goals in mind: to demonstrate to students the value of modeling so that they would apply this approach to other learning situations and to use modeling to demonstrate how both space and time are key aspects of understanding a process.
Although my ultimate goal was to get the students to create cartoons in their mind's eye, I decided I needed to start with something more concrete and accessible. I wanted an exercise that would force them to think in terms of real space and real time, an exercise that would force them to answer questions such as, "How do particular proteins interact? How does the process occur in space? What would happen to the process if a particular protein was missing? Do I have enough information to understand the function of each protein in the process? If not, what other information do I need?" In one of the first classes of the semester, I explicitly told the students that I organized information and developed new questions for my own research by creating a model of a biological process and that I wanted them to start doing the same. In other words, I wanted them to "think like a scientist."

Ultimately, I decided that the best way to get students thinking about these questions was to have the students "become" the proteins and act out the process using the "class modeling" CAT (Angelo and Cross, 1993). Using class modeling allows students to assimilate information in a kinaesthetic way (Gardner, 1993) and increases their motivation. As a test case, I chose to have the students act out the basics of how a steroid hormone (such as testosterone) turns on specific genes.

After a brief discussion and overview of the process, I asked the students (I had only four in my class) to form a single team, and I gave them a short set of written instructions. I listed four major protein players in the process by which testosterone turns on a gene and asked the students to each become one of these proteins. I also gave them a specific DNA sequence to which the protein complex would bind. Their task was then to model each of the events associated with turning on the gene in the correct temporal sequence and to interact with each other as the actual proteins would. I taped up a long roll of paper towels around the classroom on which a long DNA sequence was written. Thus, the students had to search for the correct sequence as part of the process. As one can imagine, much giggling was associated with the exercise, but it forced the students to think about the sequential order of events and to discuss with each other exactly how the process worked.

**Assessment.** The first level of assessment was simply observing how the students performed in their attempts at three-dimensional modeling with themselves as parts. This provided me with immediate feedback on what they had understood from my presentation and where they were confused. The more important assessment, however, was an assessment technique that I invented and called the "storyboard" CAT. I asked them to draw a cartoon, using symbols to represent the various proteins, of a similar gene activation event. I also asked them to provide a key to explain their symbols and a brief explanation of each panel. My goal here was to determine whether they could transfer what they had learned from the dynamic three-dimensional modeling that we had done in class to a static
two-dimensional drawing similar to what is found in most textbooks; the students were successful at this task.

I also asked them to identify one step in this process in which the mechanism was unclear and write a specific question that they would like answered about this step, in an adaptation of the "muddiest point" CAT (Angelo and Cross, 1993). By having students formulate questions, they discovered that they could use model building to help them identify what they did not know. I was pleased by the questions that the students came up with because they displayed a relatively sophisticated level of understanding. Most were questions that we do not yet have the answer to, which provided an excellent starting point for a follow-up discussion.

In summary, I thought the combination of modeling a molecular biology process using the students' own bodies, along with a later reconstruction of the model on paper, was an effective learning exercise. The only downside is that this activity would be challenging to accomplish in a large lecture room with dozens of students. It could, however, be adapted to such a class through the fishbowl technique (Silberman, 1996) in which a group of students would take on the roles of the proteins in front of the whole class and the audience would tell the actors where they should go and what they should do. As a follow-up, all of the students could then perform a similar exercise in their weekly learning group in which three or four groups could do this at the same time.

Because I have not yet applied this approach in a large lecture class, I do not have any data comparing its effectiveness with standard lecture-only methods. Based on how engaged the students were, however, I firmly believe that student understanding of how genes are turned on was much improved.

Discussion

We all found that the hands-on activities we used were highly effective in three ways. First, they helped our students' understanding of the specific concepts we were trying to teach. Second, they helped the students and us to see students' misconceptions and thus address them. Third, and most important, they helped our students learn the essential skill of visualizing biological processes.

An additional critical observation we made was that although we developed our activities for different class sizes, we found that each can be adapted for use in a different setting. For example, Zolan found that the problem-based learning approach to mitosis and meiosis was ideal for an upper-level course with an enrollment of about twenty-five students; in this setting, she could interact personally with all the students. Strome used the fishbowl technique (Silberman, 1996) to employ Innes's activity in her one hundred-student class and found it highly effective. Innes took Strome's pipe cleaner and bead kits into his small class and found them useful for
helping students to master the connection between the mathematical predictions of genetic inheritance and their physical underpinnings in chromosome movements. Thus, we are enthusiastic about what we see as the next extension of our work, the creation of a “toolkit” of ideas and activities that our colleagues can use in their own classes. (Specific material for each of our activities can be found at the Web site given earlier.) Activities for stimulating student inquiry and engagement can be introduced into a classroom at the level of between one and four per semester; it is not necessary to completely revamp an existing course all at once for the impact on student learning to be substantial (Pukkila, 2004).

References


Miriam Zolan is professor in the Department of Biology at Indiana University.

Susan Strome is professor in the Department of Biology at Indiana University.

Roger Innes is professor in the Department of Biology at Indiana University.
To teach students particular ways of thinking in the humanities, three faculty in literature and creative writing discover how to conceptualize these approaches for students and model them or have students model them in the classroom, and they assess the results on student learning.

Decoding the Humanities

Tony Ardizzone, Fritz Breithaupt, Paul C. Gutjahr

The humanities might seem to be much less amenable to the process of decoding the disciplines than the natural sciences. The precision of the sciences makes it easier to define, model, and assess disciplinary operations. But there are specific ways of thinking implicit in each discipline in the humanities, and students who do not master these approaches are almost certainly doomed to do badly in these courses. In fact, it could be argued that the nature of these disciplines makes explicit modeling even more important because students, who are quite aware that they must learn new ways of thinking in a science course, may not even suspect that this is equally true of courses in areas such as literary analysis.

The three authors of this chapter have applied the Decoding the Disciplines model to the study of literature. Each of us has begun by identifying a crucial point in our courses where large numbers of students encounter obstacles to learning. We have then defined the kinds of mental operations that an expert in the field uses to overcome such bottlenecks. We have modeled these processes for our students and given them an opportunity to practice them on their own and to receive feedback. Finally, we have sought to systematically assess the extent to which students have mastered these mental processes.

All three of us have recognized that we faced obstacles from two directions. On the one hand, we need to encourage learners to go beyond the obvious, literal meaning of literary texts, to move beyond the “expositional mode,” as Ardizzone puts it. On the other hand, learners have to develop a sense that not all products of speculation are equally valid. They have to develop criteria to distinguish between better and worse arguments or writing styles.
Ardizzone, a professor of creative writing, observed that his students' writing often lacked vitality. He defined as a crucial bottleneck the difficulty his students had in going beyond mere "expositional writing" and, for this reason, created a model of poetry writing that one could call the reverse engineering of a literary text. Starting with a famous poem, he speculated how the poet might have begun with a more naïve, expositional piece of writing. In his modeling, he enhances the poem word by word to show the transition from expositional to poetic writings.

The students of English professor Gutjahr found it difficult to distinguish between better and worse readings of a literary text. To overcome this bottleneck, he helped them discover for themselves the seemingly cryptic code within a text. This modeling fulfills the dual task of showing the students that the code is not "made up" by the professor and that there are specific metaphorical layers within a text that one can follow.

Breithaupt, a professor of Germanic comparative literature, faced a similar bottleneck in that he wanted to help students distinguish different approaches to literary analysis and to master structural analysis. He assumed that students would be able to distinguish between different approaches if they were led through it once in a game format. This eased the anxieties connected with the bottleneck, and it involved a surprise that could reinforce learning.

All three of us gave our students an opportunity to actively practice these ways of thinking, and each devised strategies for assessing students' mastery of these operations. Each of us structured his approach to make the lesson accessible to a larger number of students.

**Bridging the Writing of Exposition with Creative Writing (Ardizzone)**

"Introductory Creative Writing" is a course in the fundamentals of writing poetry and fiction that enrolls approximately 110 students. In small sections, the students read, discuss, and write short analyses of a variety of model texts (poems and short stories). They also write a series of creative exercises, as well as four fully drafted poems and a fully drafted short story of at least ten pages in length. To provide the students with a viable background in these genres, I present a weekly lecture on the fundamentals of poetic and fictional craft.

After teaching the course several times, I observed that although nearly all students successfully passed the exams and completed their creative assignments on time, a significant number had difficulty with the most basic aspects of creative writing. Despite models and advice to the contrary, their writing remained expositional. These students appeared to use the same strategies they had been taught in composition in their attempts to write a poem or story. Their work was not necessarily uninteresting or weak, but it clearly lacked the vitality of well-written poetry and fiction. I concluded
that, despite models and advice to the contrary, these students continued to write in primarily expository modes.

I identified this as a bottleneck and focused on strategies that could help these students bridge their current skills as fairly competent writers of exposition with their new, emerging skills as creative writers. To do so, I decided to model in lecture how a creative work might have been written. For this lesson, I chose Sylvia Plath's poem "Morning Song" as an example and included it among the assigned readings for lecture. During the lecture, I presented the poem to the class on a transparency and read it aloud (Exhibit 5.1).

I then posed the question, "How might Sylvia Plath have gone about writing this poem?"

I asked the class to imagine that Plath was a student in a creative writing class similar to theirs and that she had been given the following assignment: "Write a poem about someone you love and address the poem to the loved one." I told the class to imagine that Plath was taking the class shortly after she had given birth to her first child and that she chose her child as the poem's subject. I then offered them a possible opening to the poem, using sentences that the students who were writing expositively might write themselves. Key words (ones that Plath uses in her actual poem) I put in all capitals:
You were a child of LOVE.
Ted and I both LOVED each other then.
Our love was wonderful, warm, GOLDEN.
I remember Mrs. Fiore, the MIDWIFE from downstairs,
Making you CRY. The CLOCK ticking on the hospital wall.
I remember how FAT you were, your little BALD head.

In a column on the right side of the transparency, I then gave them a prompt, one they had learned from the previous lecture, “Move from abstractions to particular images.” I asked them to imagine Plath beginning the poem a second time but this time with the strategy of taking a key concept from what she had written and attempting to use it metaphorically: “Love got you started like a . . .”

Second prompt: “Be specific and concrete. Look to the draft for help.” I then offered new possible opening lines:

Love got you started like a fat gold clock.
Love set you going like a fat gold watch.

“There,” I said. “There’s a fine first line for a poem. So let’s continue.”

The midwife made you cry
Prompt: “Be specific. Appeal to the senses.”
The midwife slapped your footsoles, and your naked cry

I questioned the word “naked” and offered the following:

your shrill cry
your bald cry. Filled the room.
Filled the silence of the room.
Let us know you were alive.
Took its place in the room with us.
Took its place among the elements.

I continued to model a possible writing process for the remainder of the first half of the poem, providing prompts (to be specific, to use imagery, to appeal to the senses) and allowing the students to ask questions at any step in the process.

Following the lecture, I assessed its success through a “minute paper” Classroom Assessment Technique (CAT) (Angelo and Cross, 1993). I asked the students two questions: “What did you learn most from today’s lecture?” and “Are there any concepts you feel less sure about that you think require more specific explanation and further illustration?” Following a lecture in February 2004, eighty-four students completed the minute paper.
Table 5.1. Assessing Learning Concepts for Eighty-Four Creative Writing Students

<table>
<thead>
<tr>
<th>Concept Learned</th>
<th>Number of Comments on the Concept</th>
<th>Percentage of Total Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaping a poem through word choice</td>
<td>40</td>
<td>29%</td>
</tr>
<tr>
<td>Occasion</td>
<td>35</td>
<td>26</td>
</tr>
<tr>
<td>Using concrete images</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>Writing in the moment for first drafts</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Using similes and metaphors</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Deeper understanding of the readings</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Responses to the first question helped me assess the level of their understanding. The results have been broken up into seven categories listed in order of most- to least-mentioned concepts (Table 5.1). These responses tell me that nearly all of the students say they understood the lecture’s central concepts.

Responses to the second question helped me begin the subsequent lecture as well as bridge each lecture to the next. Sorting the answers led to six general categories (Table 5.2). Many students wrote positive comments explaining their confidence in the material, and fifty-nine of the eighty-four respondents had no questions. This feedback suggests that I can begin the next lecture with only a brief summary of the above material, invite specific questions, and then move on to new concepts.

Based on the students’ responses and a later evaluation of their writing, I concluded that the lesson was successful in helping students understand and learn a way to bridge their expository skills with the writing of poetry and fiction.

Table 5.2. Further Questions on Writing Process

<table>
<thead>
<tr>
<th>Comments and Questions</th>
<th>Number of Comments</th>
<th>Percentage of Total Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>No questions</td>
<td>59</td>
<td>70%</td>
</tr>
<tr>
<td>More on the concept of “occasion”</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Advice on the writing process and wording</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Turning the abstract to concrete</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Linking occasion to simile and metaphor</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Double and Triple Meanings in Literary Analysis
(Gutjahr)

Often in my introductory freshman literature courses, I take a moment to have students speak about what they do not like about the study of literature. Two complaints seem to always rise to the surface. First, they are bothered by the subjective nature of the enterprise. Unlike science and mathematics, there are no “right” answers, and this bothers them. It seems to outrage their sense of justice and fair play. Second, they have become convinced somewhere along the line that the study of literature is much like the process of solving an incredibly obscure code or puzzle whose answer is known only to the teacher, who frequently takes sadistic pleasure in making them guess an author’s intent or a text’s true meaning.

These complaints are interesting because, on the one hand, students are complaining that they hate the fact that there is no right answer when it comes to literary analysis while, on the other hand, they are complaining that there is a hidden right answer for which they are forced into a fruitless and painful search to discover. Early in my freshman literature classes, then, I attempt to address both these complaints by leading students into an exercise that shows them that neither of these complaints is entirely valid. Literary analysis actually demands that a student take a kind of middle road between these two positions: there may not be a right answer, but there are certainly better and worse positions to argue when it comes to what a given text might mean.

This failure to understand the basic project of literary analysis is a major bottleneck to student success. The exercise I address to strike at the root of these complaints involves a closer examination of the use of metaphorical language in literary texts. In the largest course I teach—a 280-person lecture-based course centered on a historical overview of best-selling novels in the United States—I dedicate an entire lecture to modeling for my students the process of recognizing the use of symbolic language in literary texts. I begin the lecture by shying away from the literary term metaphorical and simply ask students to reflect for a moment on how language can have double and even triple meanings in certain contexts.

To give them an example before we even begin to look at a literary passage, I show a five-minute clip from the famous Humphrey Bogart and Lauren Bacall movie The Big Sleep. I have them view an interchange in which Bogart and Bacall are sitting in a bar ostensibly talking about horse racing. There are several visual and tonal clues throughout the clip, however, that the discussion is about much more than horse racing. As they banter about “staying in the saddle,” “coming from behind,” riding “over a distance of ground,” and “coming home free,” students quickly pick up that the scene is one full of flirting and sexual innuendo. On one level, Bogart and Bacall’s discussion is about horse racing, but on another level, it is about the possibility of their engaging in prolonged and wild sex.
After discussing for a moment Hollywood production codes and how such language was often used in film noir to sidestep certain restrictions Hollywood motion pictures faced in the first part of the twentieth century, students began to warm to the idea that writers might indeed be using language in creative ways that convey multiple meanings. I then moved students to consider a passage from the text for the day, a seduction novel from the 1840s by George Lippard named *The Quaker City*. I had them turn to a page in their text and look specifically at the following passage, telling them to pay particular attention to the context of the quotation and the possible multiple meanings to be found in the language. The passage is short and runs as follows:

Lorrimer advanced toward the crouching girl. He had been sure of his victim; he did not dream of any sudden outburst of terror from the half swooning maiden as she lay, helpless on his breast. As he advanced, a change came over his appearance. His face grew purple, and the veins of his eyes filled with thick blood. He trembled as he walked across the floor, and his chest heaved and throbbed beneath his white vest, as though he found it difficult to breathe.

   God Save poor Mary, now!

   Looking over her shoulder, she caught a gleam of his blood-shot eye, and read her ruin there (1995, p. 12).

To help students with this exercise, I passed out a three-by-five-inch index card to have them record their thoughts. I did not have them put anything on these cards but the possible multiple meanings they found in these lines. I then collected these cards and moved into the lecture. This learning tool is something others have called “focused listing,” a process in which students list a variety of answers to a question at given points in a class discussion to help them gather their thoughts, offer avenues for further investigation and discussion, and serve as a point of evaluation for where they might be in the learning process (Angelo and Cross, 1993).

The lecture itself was a discussion of pornography and reform literature in early nineteenth-century America and how Lippard’s *Quaker City* is a stunning combination of both these genres. Because Lippard positions his novel as a piece of reform literature, he is careful in how he uses various lurid details within his text. After giving a number of examples from the underground pornographic literature of the time, I moved to show how Lippard’s novel functions as a classic example of a wolf in sheep’s clothing. Ostensibly, the book is a diatribe against rape and pornography, and yet it uses countless pornographic conventions as a means to seek to eradicate the immoral, pornographic literature. The book promises one thing but delivers another, much like metaphorical language offers much more than a single simple message.

Near the end of the lecture, I passed out the index cards once again and had the students engage in another round of focused listing. Returning to
the passage quoted above, I instructed the students to take careful note of the context (both in the text and from the history I have just given them in the lecture). I asked them to again list any multiple meanings they now see in the text based on knowledge of the flexibility of language and the historical context (Donald, 2002).

This second act of focused listing has a double benefit. I am able to see how much students have learned in the course of the lecture, but more important, it allows the students to see that they have indeed learned something in the course of the lecture. Students feel empowered by the exercise and offer comments such as “Wow! I see it now. This passage is so dirty!!” or “How about that, a reformer in need of being reformed. Who would have thought?”

In a sample of 220 students, the focused listing exercises were illuminating. At the beginning of the class, 23 students left their cards blank, 11 students doodled or wrote meaningless phrases on their cards, and 141 students recorded nothing on their cards beyond a simple description of the action—some variation of: Lorrimer had become passionate and he was going to rape Mary. Forty-five students actually went beyond summarizing the plot to make some attempt at a literary interpretation that played with the language.

In the second focused listing, multiple meanings abounded. Only two students turned in blank cards. No one doodled or turned in a card with meaningless phrases. Twenty-six students maintained a plot-summary answer, but the remaining 192 students offered extended answers on the multilayered and metaphorical meanings found in Lippard’s text. While only seven students picked up on the phallic imagery in the first focused listing, the second listing showed that seventy-one students now saw that Lippard was positioning Lorrimer as a giant walking phallus, throbbing with “thick blood,” “purple,” and ready to attack with its single “blood-shot eye” (Figure 5.1).

The value in the exercise comes in that it helps students to see the fun of playing with the language, along with the fact that by studying historical settings and being familiar with various literary conventions, one is able to recognize more complex patterns and meanings in an author’s word choice and rhetorical strategies. While they still might view literary analysis as subjective, they also gain an appreciation that it is not entirely so. There are answers for which better and worse arguments can be made, and often the puzzles or codes they so fear can actually be a great deal of fun to attempt to figure out.

Structural Analysis as Speculation (Breithaupt)

The bottleneck that confounds students in my course on literary analysis involves the daring aspect about any interpretation: it includes speculation. I want students not only to speculate as they interpret a passage but also to
understand that some speculations are better than others. In structural
analysis, one form of literary analysis, speculation is a part of analysis, not
the other way round.

These issues are central to my freshman course, “A Short History of
Crime: Introduction to Literary Analysis.” In this course, the students typi-
cally read an excerpt from some larger text without knowing its historical
context. Their task is to paint a full portrait of the culture from which the text
was taken, including aspects of the culture that are not depicted in the source.
I make an analogy to archeology: “You find a fragment of pottery from an
extinct society; now tell me about the rituals of love of these people, their
beliefs and fears, their artworks, their legal institutions, and so forth. Use all
information you get from the fragment to speculate about those aspects of
society that are not directly addressed in the fragment.”

This is a tricky task, one that involves several subskills to get at the
analysis of a culture through a text. To break it down into finer parts fol-
lowing step 2 in the Decoding the Disciplines model (Chapter One), I iden-
tified the key complication of this task, which is the existence of a large
array of possible approaches to come to a conclusion. To produce good
results, students need to be consistent with their approach. This array usu-
ally includes the following three elements (in order of increasing com-
plexity of analysis): reshuffling of the elements of the original text,
generalization of some element of the text (“everyone is like that”), and
structural analysis.

Over the years, I have found that telling this to students does not enable
them to do this task. When facing the task of creating different interpreta-
tions based on these three basic methods, students have significant difficul-
ties in coming to a clear judgment. Instead of modeling it myself (step 3 in
Decoding the Disciplines), I found that the sooner the students first engaged in the task, the faster they were able to do it again. Thus, I decided to have the students model it for themselves through the following playful exercise.

The students all received the same crime text, such as a disturbing excerpt from B. E. Ellis's novel, American Psycho, in which a man stabs a child in the Bronx zoo (the text appears without title or author). In groups of three or four, the students were assigned to write a short story of two or three paragraphs that elaborates elements of the text. “Killing Child at Zoo,” to create a love relationship. However, what the students did not know was that there were three different sets of further instructions regarding the method of analysis, given to different groups. Unbeknownst to them, the first group had to reshuffle the elements of the text, the second one had to generalize, and the third to employ a (given) structural comparison (based on a structural analysis).

Once they read their different stories to the large class, they were surprised to see the vast difference in the outcomes. In the discussion that followed, students were usually able to identify how differently they approached the basic task to continue the story by considering the three resulting stories. In fact, their characterizations of the differences tended to be more precise than when they judged similar stories that I simply posted on the blackboard. Having written a story themselves, they seemed eager to account for the different possibilities of how the same task can be solved. This task helps the students significantly to understand these three basic modes of reshuffling, generalization, and structural comparison.

I created an assessment, based loosely on the “defining features matrix” CAT (Angelo and Cross, 1993), that measures student performance before and after this exercise. In this technique, the students have to read a short crime text from a distant historical time period. Then they receive a multiple-choice questionnaire in which they have to select the most likely statements about the society, religion, love, and personality structure of the text (none of these are directly depicted in the text). Each question includes the option “there is not enough information to make such a statement.” To provide fair comparisons, there is an A and a B version of the CAT. The day before the practice exercise described above, half the class took the A version and the other half the B version. On the day after the exercise, the versions were reversed.

I grouped the replies in four categories: simply wrong answers, no answer (“there is not enough information to make such a statement”), an answer based on generalization, and an answer that employs structural comparison. Student responses revealed a definite shift toward structural comparison; twice as many students made structural comparisons on the day after the exercise (Table 5.3).

What I found most telling—even more than the shift toward structural comparison—was that students usually did not feel any longer that there was “not enough information” to make assumptions about those things not explicitly stated in the text. Apparently, the exercise motivated them to make...
Table 5.3. Student Responses on Assessment Questions, by Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Before Exercise, %</th>
<th>After Exercise, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrong answer</td>
<td>16%</td>
<td>12%</td>
</tr>
<tr>
<td>“Not enough information”</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Generalization</td>
<td>48</td>
<td>55</td>
</tr>
<tr>
<td>Structural comparison</td>
<td>14</td>
<td>30</td>
</tr>
</tbody>
</table>

an informed guess. In fact, there were still quite a lot of wrong answers in the week after the exercise, but the exercise seemed to provide students with the skill and will to speculate. Of course, this before-and-after assessment does not capture students' long-term grasp of the basic distinction. A much longer testing sequence would be required to demonstrate this.

I would like to close by reflecting about the pros and cons of the structural comparisons practice exercise. The basic approach here is designed for those situations in which the method of student work is an explicit topic of discussion in class (“how” questions). The main advantage of the exercise is that it provides students with firsthand experience of solving the task. They “do it” without fully being aware of it. This is both encouraging and empowering for students. The different results usually serve as clear and memorable reference points for students who struggle to keep the methods apart. The group work and creative writing aspect usually work well with all students, and they comment about the “fun” they had. The exercise is time-intensive and has a limited range of uses, namely, to compare and contrast different theoretical approaches. At the same time, it could be used with little adaptation for scientific techniques as well. The fact that students do not know that they have different sets of instructions creates a beautiful riddle for them.

Conclusion

What becomes visible in our three exercises is the difference between a mere “example” and “modeling.” In the case of how to solve a task, the professor forgoes the moment of crisis that students face when left alone with a task. However, by these modeling activities, students experience their professor in an active moment of investigating. In all our exercises, the students observe that their professor actually makes choices instead of merely presenting a solution.

References


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