Teaching with Jazz

Using Multiple Cases to Teach Introductory Biology

By Eric Ribbens

Case studies challenge students to think, to process ideas at a higher and more complex cognitive level, and to experience science as a process rather than as a collection of facts. This article describes an introductory biology course sequence that makes regular and frequent use of case studies, which the author has found has synergistic pedagogical benefits that extend beyond the benefits of isolated cases.

This article is in effect a case study of teaching case studies. I'm a biologist, more specifically a plant ecologist. Teaching is an important component of my work at Western Illinois University. I teach several different kinds of classes, including a course with a field trip to Costa Rica, a course identifying local plants that meets mostly outdoors, and a course in ethnobotany that I team-teach with an anthropologist. While I have used cases as a teaching component in some of these classes, I have mostly developed my interest in case studies for our first-year sequence of courses, and it is these courses that I intend to examine in this article.

I'm not trying to be instructive or synthetic, or to develop exciting new theoretical components in this article. Nor am I trying to indicate that I have case teaching figured out and you can achieve fame and glory by simply following my five-step plan (send in the application fee for details). Rather, this is more in the nature of a self-analytical confession, teetering somewhere between comedy and tragedy. What did I do? Why did I do it? What happened? What should I do next? The title, "Teaching with Jazz," reflects my overall attitude toward case teaching. Just as jazz is a combination of preparation overlaid with improvisation, case teaching for me has been a combination of preparation, improvisation, and chaos. I suspect I will feel the same way when the time comes to teach my daughter how to drive a car.

I've been involved with case studies for at least five years now. After participating in one of the Case Studies in Science summer workshops at the University at Buffalo, I wrote a case about a public hearing to reduce an urban deer herd. Over the years, I've written several other cases, reviewed cases for the National Center for Case Study Teaching in Science, and most importantly, included some cases in my classes. However, I rarely used more than one or two cases a semester. Often the point, as with my deer herd reduction public hearing case, was more to relax and have some fun than to learn something deeply meaningful. My wife, who teaches strategic theory, told me about the more extensive use of cases in management courses, and I wondered what a more systematic use of cases would be like.

Then Western Illinois University decided to develop a major push toward courses designed to do a better job of retaining and transitioning first-year college students. This initiative, called the First Year Experience (FYE), has morphed into a fairly complex creature, but the core of the

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concept is that every first-year student should take a course taught by an experienced teacher. The courses should be fairly small (20 or fewer students), include a major writing component, and be more than simply lecture. Discussions, field trips, group attendance at concerts, plays, and so on, are encouraged. My department head decided that the biology department should offer our two-semester introductory sequence as FYE courses, and asked me if I would be willing to teach them.

A brief description of these courses is necessary. Traditionally, the first half of the lectures are taught by one professor and the second half by another professor, in large lecture sections of up to 196 students. The labs, once 28 students but now 24 students each (in the non-FYE sections), are taught by a graduate student under the supervision of another faculty member. Biology 102 is a survey of the diversity of life, and is usually taught by a zoologist and then a botanist. It covers all of the kingdoms of life and includes a beginning treatment of the anatomy and physiology of the different groups of organisms. Biology 103 covers a set of major biological concepts, including cells, metabolism, genetics, evolution, behavior, and ecology. Departmental policy specifies four exams, laboratory attendance policies, and overall course content.

My initial interest in teaching these courses was considerably tempered by the discovery that I would have to teach about animals. *Neurons?* What's a neuron? *Invertebrate diversity?* I felt stretched enough being expected to cover fungi, protists, and prokaryotes under the umbrella of the botanical half. Even more, I was also going to be teaching the laboratories. Three of the labs explored fetal pig anatomy (my 7-year-old daughter was fascinated, my 10-year-old horrified). On the other hand, I felt I had an interesting opportunity to make a difference, and teaching 18 instead of 140 students at a time was very attractive.

Course design, of course, shapes the entire teaching experience. I decided that I really didn't want to lecture extensively about animals or my students would quickly discover my weaknesses. While I'm not afraid to tell my students I don't know something, I didn't want them to realize I was clueless! Second, I felt pressure to move away from straightforward lecturing. What if I shortened the lectures, expected students to actually read the textbook, and introduced a bunch of teaching cases?

I framed my syllabus around the labs. I read each lab and identified a set of core concepts that I thought students should be exposed to beforehand. Then I worked through the textbook to choose chapters that covered those concepts. As is typical for an introductory biology course, I ended up with too many chapters, but decided to include most of them and emphasize only the concepts I thought were important. I chopped the course into four equal time units and scheduled a test on the Friday ending each unit. Labs are taught on Tuesdays, so I planned to cover the related concepts on Mondays and Wednesdays. After juggling the schedule a little for a few holidays, I ended up with eight or nine open Fridays. I decided to use a different case each Friday, and spent some pleasant hours exploring the National Center for Case Study Teaching in Science case collection to find possibilities (see Table 1). I wrote a new case to use to teach my students about hormones (and let them learn more about me, since I'm the subject of the case). Finally, I planned to include a significant writing component after each case, to have my students also keep a weekly journal, and to divide them into groups of four. My idea was that they would work through cases in small groups, even develop the writing assignments as a group.

I wish I could tell you that my class worked wonderfully, that my students blossomed, that I simultaneously made my teaching look gifted and effortless, and that everything went as planned. Instead, I discovered the art of improvisational teaching, particularly in regard to the cases. Frequently I found that I was making adjustments, sometimes on the fly. Adding assignments, changing assignments, dropping some components of the case, and emphasizing others: the cases were a more fluid teaching component than I had previously experienced. Why?

As I reflect on this question, I think the answer lies buried in my teaching philosophy. Here's my statement of teaching philosophy, taken directly from one of my syllabi: "I am convinced that effective learning must include two components: adding new concepts into a cognitive framework, and developing the skills to independently evaluate new information and incorporate it into or modify the cognitive framework. In today's society, information is collected and made available at an ever-expanding rate. It is essential to teach students how to handle information, make decisions based on evidence, develop conceptual models from their sets of information, and assess the quality and relevance of information to a particular problem. Therefore, I have a five-fold teaching philosophy. I believe that: (1) the material I am teaching is fascinating and fun, (2) students and professors are accountable to each other, (3) both students and professors should be treated with dignity and respect, (4) my students and I are co-travelers on the same pursuit of knowledge, and (5) it is vital that my students are challenged to think about science and its relevance to their lives, not just memorize information."

Notice that I emphasize the ability to manipulate conceptual objects within a theoretical framework. I've often thought that if biology were about bicycle riding, we would learn the theory of balance, discuss different strategies of racing, do a series of labs in which students learn to take bicycles apart and perform basic maintenance, perform another lab in which they get to briefly sit on a bike, and then we'd tell them to go compete

TABLE 1

Cases used fall 2005 and spring 2006, arranged by chronological order in terms of their use.
All cases are available on the National Center for Case Study Teaching in Science website at *http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm*

Case	Course	Comments
Ribbens, E. Chemical Eric: Dealing with the Disintegration of Central Control. Chronicles the symptoms, medical conditions, and crises of a boy with a pituitary tumor.	Bio 102 (1)	This autobiographical case study served to introduce me to students and made the hormones we were learning about come to life.
Ribbens, E. Eating PCBs from Lake Ontario: Is There an Effect or Not? Based on a real news release, teaches students about statistical analysis and experimental design.	Bio 102 (2)	This case got their attention, but they did not achieve my goal, which was to think about the spin put on research announcements. Instead, they wondered why someone would do an experiment that didn't produce clear results.
Heidemann, M., and G. Urquhart. A Can of Bull? Do Energy Drinks Really Provide a Source of Energy? Students analyze energy drinks to determine whether they nutritionally match their marketing claims.	Bio 102 (3)	The students really got into the analysis of sports drinks from both the perspectives of content and advertising.
House, H. The Hot Tub Mystery: The Story of a Very HOT Tub. Students investigate cause of death in this case study about blood pressure regulation.	Bio 102 (4)	This case was less relevant to the course material and students' attention wandered.
Grant, R.H. A Strange Fish Indeed: The "Discovery" of a Living Fossil. Recounts the 1939 discovery of a living coelacanth, a fish believed to be extinct for over 70 million years.	Bio 102 (5)	The idea of a living fossil and a poorly understood vertebrate intrigued students.
Morris, T.E., and S. Gal. A Recipe for Invention: Scientist Biographies. Students research and write about the personal and professional lives of scientists.	Bio 103 (1)	I really like this one for its use of outside resources, and because it allows students to show some initiative.
Bailey, C.T. Thinking Inside the Box. Students work in small groups to make indirect observations about objects in a sealed box.	Bio 103 (2)	Initially students gave superficial answers, but with some prodding their competitive natures kicked in.
Ginn, S.R., and E.J. Meinz. A Rush to Judgment? A Case of Research Ethics and Design. Describes a research study conducted by students in which a number of ethical and design issues arise.	Bio 103 (3)	This one nicely highlights possible dilemmas in the process of doing science.
Bode, C., and A. Jablonski. A Rigorous Investigation. Students investigate the cause of death in an incident that occurs in a research lab in this case study about cellular respiration.	Bio 103 (4)	This case tied in well with our discussions on mitochondria, but was somewhat repetitious.
Vail, S., and C.F. Herreid. Little Mito: The Story of Where He Came From. Fanciful case that explores the origins of the eukaryotic cell.	Bio 103 (5)	Students thought this case was too easy.
Aronova-Tiuntseva, Y., and C.F. Herreid. Hemophilia: The "Royal Disease." Uses the spread of hemophilia in Queen Victoria's descendants to illustrate principles of genetics.	Bio 103 (6)	This case tied directly to our study of genetics. In particular, students liked the problem posed at the end of the case.
Pals-Rylaarsdam, R. The Evolution of Creationism: Critically Appraising "Intelligent Design." Explores the claims and criticisms of Intelligent Design.	Bio 103 (7)	I focused on questions 2 and 3, which ask students to list the claims and criticisms of ID. I appreciated this case's focus on the scientific merits of a major current controversy.
Benson, K. My Brother's Keeper: A Case Study in Evolutionary Biology and Animal Behavior. Students interpret behavioral data in the context of evolutionary biology in this case study on kin selection.	Bio 103 (8)	Many of my students had trouble with the math; next year I will explain the formula better.
Ribbens, E. Treating Ed. Students consider the ramifications of advance directives and durable powers of attorney in making medical decisions about their care.	Bio 103 (9)	I used this case in the context of an extended discussion about ethics.

in the Tour de France. Similarly, I am convinced that we spend so much time building the framework that students don't learn how to adjust it or work within it. Biology gets reduced to a collection of facts that dangle from a theoretical framework, and as a consequence, students don't develop a deep understanding of biology as a way of exploring and learning about the natural world.

So how does this apply to introductory biology? My introductory biology courses have several components. The textbook-oriented days often resemble a combination of discussion and lecture. I use them to create a conceptual framework for understanding biology. We tend to focus on the bigger picture: the theory that has been built to explain biology. Consider, for example, the field of plant ecology. Why have flowers evolved into so many shapes, with their attendant colors and smells? Answer: to manage the animals that pollinate them, restricting access to some and attracting and rewarding others. It is this conceptual level that I want my class to reach on Mondays and Wednesdays.

In contrast, the Tuesday labs are designed to give students direct encounters with biology. They learn different techniques, start to collect information, and explore real biological objects. Discussing digestion conceptually is quite different from dissecting a fetal pig and tracing the pathway of food from mouth to anus.

What I have found is that my Friday cases meld nicely into my teaching philosophy, and in fact fit into my course goals better than the laboratory experiences. If the lectures and textbook component build a conceptual cognitive framework, the case studies allow students to learn to work within that framework. In other words, students learn how to, in the words of my teaching philosophy, "handle information, make decisions based on evidence, develop conceptual models from their sets of information, and assess the quality and relevance of information to a particular problem." Cases are also particularly good at touching the fifth component of my belief statement: challenging students to think about science.

Another way to explain this is to consider the scientific method. We've all learned that a scientist takes a pattern, develops a hypothesis to explain the pattern, designs an experiment to generate data to evaluate the hypothesis, collects data and uses the data in the evaluation process, and then refines or refutes the hypothesis, which may eventually become a theory if repeatedly supported. Lectures work well with the first and last components of this process: building the hypotheses into theories and using these theories to explain the different patterns we observe. Laboratories work well with the collection and generation of data through experimentation. We can hypothesize that auxin suppresses lateral bud growth in lecture and we can experimentally show this in a laboratory. However, the downside to laboratories is their limited focus. In two or three hours the experiment must be done, data collected, and the lab wrapped up. Often the connection to the initial hypothesis or to the final reevaluation stage is slighted. Moreover, there is a terrible pressure to "make the experiment work," which can lead students to think that science always produces the right answer within three hours. If lectures are all head activity, laboratories tend to be all hands-on activity, and this compartmentalization hinders the development of understanding how science works.

Cases tie the scientific method back together. A good case acts like a vine, wandering over the framework of the scientific method and entangling it all together. The case illustrates the theory, presents the results of an experiment, or challenges students to explore a problem in search of a solution or solutions. Cases are sometimes dismissed as not being conceptual enough and not being good at generating data. I used to use cases as teaching ornaments. It is through my regular employment of cases that I have come to appreciate what a marvelous teaching opportunity they can be.

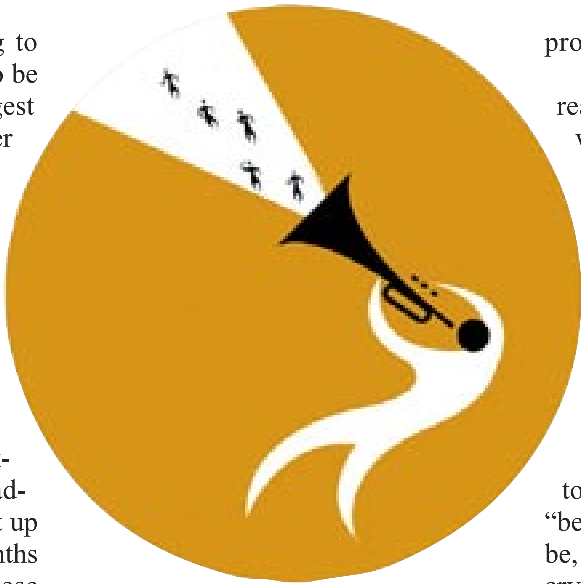
Cases let us explore things that can't be experienced in three hours. They can act like illustrations, fleshing out the abstract conceptual framework that a typical lecture builds. But in particular, a good case can challenge students to manipulate the scientific method. Cases can work effectively with hypothesis development, research design, data analysis, and the hypothesis reevaluation pieces of the scientific method. I've found that while my students can describe the scientific method conceptually, they have a very limited experience of it. As one of my students wrote last fall, "I don't really like the cases. They force me to think, and I'm better at memorizing facts."

Therefore, I am convinced that cases are as, or even more, important than the laboratory experience in helping students understand the scientific method and adding color to the theoretical framework. Second, cases are a good avenue to introduce spontaneity and to let go of control—to, in effect, teach "jazz style." This spontaneity can be divided into three components: letting go of control, redesigning cases to make them fit the course, and discovering opportunities for creative customization during the teaching experience.

First, what is the spontaneity of letting go of control? I prefer to teach cases involving many small group experiences, and I often have my students work through a component in their groups, convene the entire class to consider the results, and then split them back into small groups to continue. There is no way that I can monitor and lead five different small groups simultaneously. I've had to learn to trust the process and to accept that sometimes groups don't work the way I think they should. Typically, I give the class instructions to work in small groups, and then sit in the back of the classroom and watch. I'm trying to signal that I'm not in charge of the activities. I'm also watching to see if any of the groups appear to be dysfunctional. Probably the biggest challenge that I regularly encounter is groups that are seeking leadership. I've found that picking a student often greatly improves results: "Sarah, I'm going to expect you to summarize your group's decision in a few minutes." Setting up a rotation ensures that every student takes a turn being the leader. Sometimes I'll walk around and listen in, looking for an opportunity to ask a leading question. "So, you plan to set up movie cameras to watch coelacanths in the ocean. How deep are these caves? Can you rely on sunlight for your illumination?"

The more uncomfortable component of letting go of control for me has been learning to accept that groups may fail. If the class is reconvened to sort through the answers, it becomes painfully obvious when one group is substantially underperforming. Related to this is the challenge of dealing with flawed logic. I've found that it helps if I repeatedly tell my class that when I ask questions I'm not attacking them as persons. But the best way to handle this is to be open to critical thinking from the students: I'll often introduce a bad idea in order to give them the opportunity to practice critical thinking and to let them see that sometimes I'm wrong.

Second, what is the improvisation of redesigning cases to fit the course? I'm discovering that a good case can be modified, and that a great case that isn't appropriate for the course won't work well. For example, I tried to use a debate case early last semester. I didn't adequately prepare my students. Moreover, I wasn't expecting that it would be much easier to build arguments for one side than for the other side, and the entire event imploded. I ended up canceling the case. I'm slowly learning that redesigning follow-up writing components or even condensing or omitting case components can be done.



It turned out that my students are so used to thinking of science in the context of canned labs that they were baffled by the idea that research might not produce the desired results.

Third, how do you spontaneously incorporate unforeseen learning opportunities? I've found that cases often show me that my students are at a completely different place than I thought they were. A good example happened early last semester when we analyzed a press release about PCB impacts that I wrote a few years ago. I designed the case to show students the illogic of attempting to spin results that aren't statistically supported, but my Introductory Biology students were stuck on a much more basic point. As one student blurted out, "Why did they waste all that money on something when they didn't get the answer they wanted?" It turned out that my students are so used to thinking of science in the context of canned labs that they were baffled by the idea that research might not produce the desired results.

Cases can also be important reality checks. For example, after we worked through the coelacanth case (see Table 1), I asked my students to design a research project describing what they would do next if they were graduate students studying them. Most of the groups developed plans to do things like videotape coelacanths in the wild, or to collect one and keep it alive in a laboratory, but one group planned to go fishing until they caught one, "because if we actually got one we'd be, like, bad fishing dudes, and everyone would be totally jealous!" Not exactly the result I was hoping for. Another example occurred during our exploration of an ethnobotany case that I wrote. My best student wondered, "Why didn't the scientist just find a few volunteers to try the new drug to see what happened?" This led nicely into an impromptu discussion of placebos, something they had all heard about but did not understand particularly well.

So, what have I learned about teaching with cases, especially using cases on a weekly basis? First, be prepared! Plan through the entire case experience, and try to think like a student. What will you do when such and such happens? Probably the most important piece of preparation is simply choosing the case in the first place. Why do you want to use that particular case? How will it fit into your teaching goals? What specific results are you expecting, and how can you measure those results? I've discovered it is less important that the case fit tightly within the context of the rest of the course than that the case fit within the level of the class and within the exploration of the scientific method.

Second, be flexible! While classroom control is desirable, it's okay if you don't always follow your preconceived plan. For example, a case I wrote about hormones turned out to deeply affect one of my small groups, especially when they realized that I was the subject of the case. Did I have an unhappy childhood? How do I deal with the lingering effects? What was it like to be hospitalized for over a month at a time? It turned out that several of the students in that group hoped to be doctors and were being confronted in a way they hadn't been before with the idea that medicine isn't always a kill-or-cure, acute crisis. I let them drop the planned small group topic and instead explore ways that doctors can anticipate and mitigate medical impacts.

Third, manage your small groups. In particular, you need to plan how you will grade them. Students often worry that there will be a slacker in the group who will benefit disproportionately. I encourage students to commit to their group, to find ways to informally reinforce good group behavior, and I tell them at the beginning of the course that they will be able to evaluate each other at the end. Usually for this evaluation I give each group member 100 points that they can distribute among the group. In a group of four students, if you think everyone participated equally, give everyone 25 points. If someone was especially hardworking, increase their point load; if someone didn't contribute, reduce their points. I then review their ratings and if there are major disparities within the group, I'll ask them to come talk to me about it; otherwise the group component of their grade is adjusted by their relative group rating.

Students often wonder why group work is at all important. I tell them that employers routinely indicate that an ability to work with others is essential, but last semester by far the best reinforcement occurred during a tour of our local hospital, when the emergency room director told the class that being able to work as a group in a hospital setting was one of the most important job skills. I'm still struggling with how to build groups. Students complain if I assign them to groups, and they complain if I let them form their own groups.

I don't want to make it seem that there are no problems with teaching with jazz: sometimes the band cooks, sometimes not. Problems can be due to me, to students, or to perceptions from outside the course; in particular, problems pop up during evaluation processes. By far the most difficult and common problems are my fault. For example, I've found with my first-year students that it is important to give them minimum-page requirements for their writing assignments. When I work with upper-class students I can get away with telling them to start at the beginning and keep going until the end, but my first-year students need more guidance or they will turn in three scrawled sentences instead of a detailed essay. Students often erroneously see case studies as fun and therefore frivolous, so they either become frustrated because it isn't "real learning" or they think they don't need to apply themselves. I've found that clear goal-setting helps considerably. I tell them up front what my main goal or goals are for the case, and occasionally I ask them to review those goals and evaluate the cases in terms of their effectiveness. I've also found that they buckle down considerably after their first bad grade, so definitely follow your first cases with a graded assignment. Having students keep course journals can be illuminating. I've discovered that cases I thought were really cool bored many of my students and have sighed over the apparent inability of some students to grasp the concept I wanted them to discover.

Perceptions from outside the classroom can also be important. Why am I using valuable class time on a case study? If we do cases, doesn't that mean that students learn less? If my classroom is a noisy agglomeration of small groups loudly debating an issue, am I still in control? Being tenured helps, but be prepared to calmly explain your reasons why you think using cases is important. I've found explaining my reasoning about exploring the scientific method, plus the university requirement that my class have a considerable writing component, have helped.

Evaluations by students are often an important component of professorial retention and promotion. Sometimes students think that case teaching is easier for the professor, or that the professor isn't acting appropriately. Other students dislike cases because they move students away from the lecture mode with which they are comfortable (albeit bored). Again, I've found that sharing my goals helps defuse some of these issues. Next spring I plan to have my students vote for the case that they liked the best, in an attempt to get them involved in thinking about the differences cases make.

I also have some suggestions for case writers. First, make your case generalizable. Forcing it to fit within a specific textbook or into a 75-minute class with five groups of five students is not very realistic. Second, look for immediacy. One of the big advantages of cases is their concrete connection to relevance. The case I wrote about the impacts of PCBs on women's reproductive health is a rather dry press release. If I could rewrite it, I'd change it so that a young woman trying to get pregnant would be eating a meal (fish from Lake Erie) while anxiously reading the press release in the newspaper, and I'd have students help her figure out what to do. There is a reality created by well-designed fiction that can considerably enhance the impact of a case, enabling students to move from the abstract conceptual framework of a scientific idea to its impact on someone's life.

In conclusion, I advocate the regular, even seemingly extravagant, use of cases. If you want your students to move up the taxonomy of learning from factual memorization to an ability to move back and forth from theory to concrete application, good case studies can greatly facilitate this. Cases are not a panacea. A bad teacher will still be a bad teacher with cases. Planning in combination with teaching jazz makes all the difference. And it can be fun! ■