Curriculum Case: Genetic Diseases
Icebergs and Apprenticeship

It was the first week back from the New Year vacation. On Monday, my students looked bright and rested from their vacation. By Tuesday and Wednesday, however, the 7:30 am starting bell was beginning to take its toll. As the week progressed my kids looked more watery-eyed and sleepy every day. How could I keep these tired teenagers engaged in my weeklong unit?

I taught a regular biology class at an ethnically diverse high school in the San Jose area. My class of freshmen and sophomores reflected the diversity of the school population of students. My students were white, black, Filipino-American, Asian-American, Persian, and Hispanic. Although their families came from all over the world, most of the students were fluent English speakers. At least one student was mainstreamed ELL, but no students had obvious language problems. The class was about 60% male, 40% female. The students were as diverse in their academic preparation as in their ethnic backgrounds. They varied widely in reading and writing skills, as well as science experience. In spite of the variations, there was a good feeling of community in the classroom. My CT had made community-building activities a priority at the beginning of the semester. Every student knew the name of his/her classmates, and behavior problems were extremely rare. Generally the students were friendly and polite to each other in class and in small groups.

All students at this high school are required to take two science classes. Most students take an integrated science class their freshmen year, and then take biology. A few freshmen waive out of integrated science and move directly into biology. There were four such freshmen in this class. There is no "honors" course for biology. If a student wants to pursue advanced biology, an AP course is offered to students who have already taken regular biology. It was a challenge throughout the semester to meet the learning needs of each of my students. For example, there were about three or four students whose abilities, science skills, and interests were far above the demands of the curriculum. These students always knew all the material required, and then some. I knew they were not being challenged. At the same time, I had students who had failed biology before, and were retaking the class. They struggled to turn in work on time, and needed much more scaffolding to complete lab reports, do graphs, and understand more complex material. In addition, while a majority of students said they learned the most from group work and group tests, there were some who adamantly opposed group tests and said they liked lectures the best. With these different needs in mind, I tried to design my unit to incorporate as many learners as possible.

My high school operates on a block schedule. Each day the students come to class for 90 minutes, and at the semester end, the entire schedule rolls over. Because all the classes turn over at the end of the semester (like a university schedule), this unit was taught at the end of the course. The week I taught my unit was one of the last weeks the students were in my class.

This was the first opportunity I had to create and teach a unit on my own. My cooperating teacher had planned time for our students to learn about genetic and infectious diseases, and back in October, she had handed the subject over to me. I seized the opportunity to teach what I felt

was a relevant and interesting topic to my students. My CT gave me full responsibility over the unit, and although she offered support, it was completely up to me to decide upon the objectives, design, and implement the project.

I was excited about the unit because it really was the first topic in biology that we had studied that would be directly relevant to them. Instead of practicing Punnett squares with pea colors, they would be studying genes, disease, and their bodies. My goals for the students were for them to 1) use the basic principles of genetics to understand how one can inherit and develop a disease, 2) learn about technological advances in the field of science and medicine, and 3) consider ethical issues of disease, society, and research. My challenge was to help them make connections between the abstract principles they had learned, and were learning, and real life situations.

In the past three months, my students had learned about cells, genetics, and evolution. However, I didn't think they really had grasped the importance of what they had learned, and I certainly hadn't seen a great deal of interest. I felt that by studying specific genetic disorders, my students would see the relevance of the principles they had been studying. As Bruner stated, "The best way to create interest in a subject is to render it worth knowing, which means to make the knowledge gained usable in one's thinking beyond the situation in which the learning has occurred." I felt they had learned enough of the basics to apply their knowledge to real-life situations. I wanted to give the students an opportunity to research and learn about a specific disease in the context of what they had learned. I hoped that by doing this, my students would really delve into the material, and learn about their disease in-depth. I chose four different genetic diseases for them to study – hemophilia, sickle-cell anemia, Huntington's disease, and cystic fibrosis. I chose these four diseases because there is plenty of information about them, they all have different inheritance patterns, and because certain diseases tend to be more prevalent in certain population groups that were represented in our class. For example, sickle-cell anemia has a higher incidence in the African-American population, cystic fibrosis mostly strikes Caucasians, hemophilia affects mostly males, and Huntington's disease affects different ethnic groups.

The students had ranked their preferences for the disease they wanted to study, and I had divided them into eight groups of four according to their preferences. All the African-American students requested sickle-cell anemia, at least half the class wanted to study Huntington's (they thought it was amazing how you could seem normal and then suddenly start losing your mind), and only a few wanted to study cystic fibrosis because it was "yucky." Every student was able to study his or her first or second choice. The students were excited when they got their first choice, and disappointed when they got only their second choice. I was pleased at the initial interest in the topic.

My students had worked in groups on many occasions in this class, so doing another group activity was not a big deal to them. I never heard a peep out of my students about dividing up into groups. Although the groups were decided by individual preferences, I still had some room to manipulate the makeup of each group. I decided to make the groups heterogeneous by academic ability, gender, personality, and ethnic background. Since the project was research-based, wanted at least one academically strong person in each group. I handed each group an

ethical dilemma to solve regarding their disease. An example scenario: a research company wanted to hire a man who they thought would be an excellent addition to their staff of scientists. However, they found out he had the allele for Huntington's Disease, which meant there was a 96% chance he would develop the fatal symptoms within 15 years. Should the company hire him? Why or why not? I was hoping that by providing an interesting scenario, the students would see a reason for bothering to do the research. Instead of presenting a report on a disease, they would be applying their knowledge to a plausible case. My goal was to balance the content with the ethics. I later realized I didn't make this clear enough.

Over the course of the week, each group had to resolve the dilemma by researching aspects of the disease. At the end of the week, the groups were to present the resolution of their dilemma and information about their disease in a skit presentation in front of the class. This project would show the culmination of their research, and they would have the chance to teach each other. Although groupwork was not new to my students, research projects were. In addition, my students had only done one small oral presentation in front of the class – and that was at the beginning of the year. I hadn't realized quite how ambitious my expectations were. In my planning, I had "chunked" the unit into manageable portions, in order to scaffold the learning process. Although my unit was only a week long, I had attempted to design it the same way one would design the kind of curriculum advocated by Dewey and Shulman. "A curriculum is a carefully structured and sequenced set of topics and their representations designed to facilitate their acquisition and understanding by the students." The word, "unit" could easily replace "curriculum." On Monday, I was to introduce the unit, review key concepts, and the students were to research inheritance patterns for their disease. On Tuesday, the students were to learn about causes and effects of their disease. On Wednesday, the themes were treatments and gene therapy. Thursday, they were to analyze their information, resolve their dilemma and plan their skits. Friday, they were to present their skits to the class. Each group handed in a group product daily. For example, on Monday, they handed in a worksheet that detailed their disease's inheritance patterns. On Tuesday, each group completed a poster describing their disease. In addition, each student was responsible for answering questions on an individual worksheet. The purpose was to allow me to monitor group and individual needs. I had books, texts, articles, and videos for their use. In addition, we went to the library, and the students had Internet access all week. I thought I had designed and scaffolded a unit that would promote deep understanding.

Essentially, the unit went according to schedule. The students dutifully took notes when I lectured, they completed their group worksheets and posters, and they prepared and gave their presentations. Students researched and developed skits on schedule. On Friday, the culmination of the week's activities, they all presented their skits. One group, presenting Huntington's disease, did a fantastic job. Sally, Liz, Marcus, and Jeff created fake adoption files and wore lab coats as props, every member played a role, and they were informative and entertaining. They answered every content requirement on their task sheet and performance rubric. For example, they knew which chromosome contained the disease (#4), and they even knew that the mutation caused a "genetic stutter" which was a concept we had never discussed in class. They told us about specific symptoms, as well as the only treatment available. In contrast, a different group presenting cystic fibrosis did a horrible job. Only Mark and Don spoke, reading from an incomplete script, and there were long pauses between lines, as all four group members eyed each other, wondering who was supposed to speak next. They never referred to their poster. The

group also had large gaps in their content explanations. For example, they did not explain inheritance patterns. The other groups' presentations were somewhere in between. They were informative and completed most of the requirements, but either missed a key content area or a group member didn't pull their weight in the skit. Overall, students had done their work, and they presented their material. I had helped to guide them to a point where they could do a skit on a disease and resolve a dilemma. Why was I feeling a little disappointed?

In spite of all the scaffolding I felt I had done, the students still didn't do exactly what I had hoped they would do. I had hoped that this would be an opportunity for students to research, discuss, make connections, and apply concepts to real life situations. My goal was for the students to think critically and examine a situation in depth. In the end, I didn't see the depth I was hoping for. The students did minimal research – they didn't really search the articles I had laid out for them. Most groups never really looked for or showed understanding for the details of the disease. For example, the cystic fibrosis groups dutifully drew chromosome #7 and pictures of lungs on their posters, but they never understood that malformed chlorine channels in all epithelial cells are what cause the symptoms of the disease. In their individual worksheets and in their skits, the students skimmed the surface, and there were gaps in almost everybody's work.

I had given them a rubric ahead of time, and we had looked it over as a class, so they were supposed to know what was required. They didn't. For example, I had asked my students to tell us in the skit if gene therapy was being researched for their disease, if it worked, and how it worked. But even after a careful lecture on gene therapy, only one group asked for help. When I pointed out articles to this group, only one of the students gave them a passing glance. I was frustrated that all my efforts at tracking down materials seemed to be wasted. That was the only group that mentioned gene therapy, and they did not discuss details at all. It seemed like nobody looked at the dozens of current articles I displayed for this purpose. What could I have done to promote more rigorous research, thinking, and answering of questions? Why had they missed some key concepts when everything was practically handed to them? Were my expectations unrealistic? How could I have supported my students better? Why were certain groups were more successful than others? How could I have ensured that everyone learned in each group?

These questions turned over and over in my mind as I reviewed the events of the past week, and analyzed the strengths and weaknesses of my unit. Essentially, I felt my main disappointment came from unfulfilled expectations. In turn, these unfulfilled expectations stemmed from my lack of providing necessary support. In my mind, I had a vision of what I wanted the students to do. In my plan, I had scaffolded the unit and provided the necessary resources for them to accomplish it over a week's time. But I did not share my thinking with my students! I did not make my thinking "visible." As I reflected on my experience, I realized that Donald Norman's "Iceberg Model" fit my situation exactly. Norman describes how an iceberg has only a small portion visible above the surface of the water, whereas the bulk of the ice is lurking underneath. "From the point of view of the learner, the part of the iceberg that is above the surface of the water is the material that is presented." The learner must to try to figure out "the underlying structure." During the week, I gave thorough mini-lectures full of diagrams and visuals, about cells, genetics, gene therapy, and disease. I expected them to be as thorough on their own explanations of their diseases. But I realize I never really told them that. I glanced over their work during the week, but I never gave detailed feedback, either orally, or in writing,

that could have pushed them for further detail and evidence of critical thinking. An example of a question on a worksheet was "draw how a virus delivers DNA to a cell." I didn't tell them to explain or elaborate the whole process of gene therapy in detail, but in my mind that is what I wanted to see, since that is how I explained the process in my previous lecture. I assumed they would also provide descriptions of their drawings that would show evidence of their understanding. I assumed wrongly. It made me reflect on how I worded the questions on their assignments, which I realized was a crucial element of making my thinking visible to my students. I collected their individual worksheets at the end of the unit, and graded them after the unit was over. But that didn't help them while they were researching.

I dove into the unit thinking that I had designed plenty of scaffolding into this project. But I discovered that scaffolding is not just giving my students a timeline, a rubric, some daily group worksheets, and individual worksheets. It's laying out expectations and teaching the skills required in order to complete each piece of the project. I needed to model, scaffold, and coach each piece of the unit. I should have worded my questions more carefully, and discussed in more detail what I expected of them. I should have modeled exactly the sort of answers I was looking for by perhaps doing an example project. I know I was disappointed that my students did not draw from much of the material I provided for them, but now I realize that some students might not have had the skills to do so. It was my job to teach those skills.

Allan Collins describes the process of "cognitive apprenticeship" as a means to support the students in teaching these academic skills. As a traditional apprentice learns by his master's "modeling, scaffolding, fading, and coaching," so can a student learn from me if I utilize these techniques and "deliberately bring (my) thinking to the surface." It was obvious I needed to do more than "scaffold" to help my students reach my goals for them. Cognitive apprenticeship requires the modeling, fading, and coaching as well – in areas I hadn't thought to consider. And then it requires that I make my thinking process clear as I explain. I needed to consider my students my "apprentices" in learning research skills, groupwork skills, presentation skills, consideration of ethical issues, and much more!

The students would have been more effective at researching if I had provided them with the tools for pulling important information out of articles. It would have been helpful to model and practice with an article. The students needed to know how to read the articles, gather relevant information, take useful notes, analyze, and do something with their research articles. I had assumed they already knew how to do this. Some did, and some didn't.

Ideally, the students should have had more practice previously doing oral presentations, as well as giving and receiving feedback. As I reflect upon what made some groups successful, and some not successful, I realize that group skills are important to teach explicitly. They had worked in groups often, but this time I tried to use norms and roles they were unfamiliar with. I still think the group combinations were adequate, but many students did not have the skills, or desire, to work effectively together. As Cohen states, "It is a great mistake to assume that children (or adults) know how to work with each other in a constructive collegial fashion…Although many students have had some contact with cooperative learning, often they were given no preparation for that experience." Groupwork skillbuilders would be effective at the beginning of the semester (not the end), as would constant enforcement of norms and roles. I

explained expectations for groupwork, but did not do a good job of enforcing. It was hard to do at the very end of the semester. I believe that the group of two boys and two girls that did the most excellent work, in spite of vastly different academic situations, ethnic backgrounds, and social statuses among its members, did well because they had interest in what they studied, and they treated each other nicely. The group that failed could have used enforcement of norms and skill builders because they naturally did not get along, they weren't too interested in the project, and nobody ever took a leadership role. The other groups had at least one or two students who took charge, and pulled the others along. I concluded that more important that group composition was enforcement of group participation norms.

I had to provide constant feedback, or "coaching, " throughout the week. I did not appreciate this enough at the time. To give myself a little credit, I did give some feedback along the way. If students were totally off, or really missing information, I let them know it. I directed students to resources, and prompted group members to work together, but I didn't push enough for thinking and more research. It is obvious now that throughout my unit I only exposed "the tip of the iceberg" in spite of my well-intentioned scaffolding. I expected a lot more that I unwittingly kept hidden underneath the surface.

These thoughts led me to question the entire design of the unit. Was this the best way for students to learn the material? I had based my unit around student research projects, culminating in a presentation. The key was for students to work together in groups. Because of the diversity of backgrounds in my class, I hoped that the groupwork, the poster designs, the research, and the skits would help every classmember learn by tapping into different intelligences. In "Multiple Intelligences in the Classroom," Thomas Armstrong summarized Gardner's work and pointed out that the seven Intelligences (or more) not only have a theoretical basis, but they can be utilized in the classroom. If this were true, I hoped that kids with strong linguistic intelligence would learn from the reading and writing portions of the unit, those with strong spatial intelligence would be helped by the poster design, and those with bodily-kinesthetic and interpersonal strengths would do better with the presentations. In the end, the typically high academic achievers did well on their worksheets and research. But I was especially happy to see how a few academically low-achieving students were the stars of the skits. For example, Al, a normally quiet boy, came to the front of the class holding a stuffed monkey in a ballet costume, and was the star of the show as he played the "husband" and the monkey played the "wife."

My students gave me feedback as to how the unit went for them. Most of them declared that they learned more in the group format, but most really disliked doing research and skits in general. One student, Dave, thought it was "cool" that they got to perform, but I found that most students agreed with Casey when he wrote on his feedback form, "I HATE skits!" It was hard to get specific reasons out of my students, but I generally got the feeling that the work of researching and reading was tedious for many kids, and performing in front of 30 people made them nervous. It was a lot to ask a group of students to research as a group and prepare a skit when they hadn't done it before in the class.

This is a unit I will teach again. I feel that the basic scaffolding principles tied everything together very well. However, I will implement the unit differently next time so that my expectations for the rigor of research and thinking may be matched by their performance. That

can only happen if, throughout the year, I make it a practice to make my thinking explicit to my students, or expose the bulk of the "iceberg." In my own ideal classroom, I would do group projects, oral presentations, and projects throughout the semester where I would practice the principles outlined as cognitive apprenticeship. This way I hope the students will learn what it means to do an excellent presentation. The students will learn to work together and research projects. It's important to establish expectations in these areas early on – not at the end of the semester! My hands-off policy allowed one group to fail. The students need more than a rubric to know my expectations. They need daily feedback in writing, and orally. I need to practice giving the detailed feedback that will push for further understanding and details. And I need practice prompting groups to work together more effectively. Although I thought I scaffolded my entire unit nicely, I realized I missed teaching and scaffolding the skills required to complete the unit. The elements of apprenticeship I need to implement may take more than the week's time I originally allotted to my unit.

Overall, I felt my students really did learn. Almost all of them said so on their evaluations. I just don't think they learned enough. I seek to teach for real understanding and depth of knowledge. Next time, I hope I can make my thinking clear, and implement the strategies that will actually support my students in achieving that goal.