Fostering Inquiry through Problem-Based Learning

Students learn the role of genetics counseling and gene testing in the identification and treatment of cystic fibrosis

Karen Goodnough and Marie Cashion

As university researchers and teacher educators, we believe problem-based learning (PBL) has tremendous potential to foster inquiry-based teaching and learning. With current reform initiatives in science education focused on promoting active learning and higher-level thinking, more teachers need to adopt a range of innovative instructional and learning strategies (AAAS 1989; NRC 1996).

We have developed a PBL model that presents high school biology students with a genetics problem involving cystic fibrosis (CF), in which students place themselves in the role of a genetics counselor. Through this PBL experience, students actively explore an open-ended problem with more than one solution.
Cystic fibrosis

CF is a complex genetic disease prevalent in the Caucasian population, although it does occur to a lesser degree in other ethnic and racial groups. In the United States, 1 in 3300 live-born children has CF (Genzyme Corporation 2003). The defective gene is found on chromosome 7, resulting in the production of a faulty protein that causes an imbalance in chloride and sodium ions. Consequently, people with CF produce abnormal amounts of thick mucus that clog the lungs, making breathing difficult and placing the person at risk for infection. Also, mucous may block pancreatic ducts, thus interfering with proper digestion. Although there is no cure for CF, with current advances in research and technology patients are living much longer into their 20s and 30s.

To be born with the disease, a baby must inherit two recessive, faulty genes (one from each parent). Thus, a parent may be a carrier for the gene but not have the disease. Likewise, children of this parent may also become carriers and not be affected by the disease. If both parents are carriers, there is a 25 percent chance the baby will have CF, a 50 percent chance the child will be a carrier, and a 25 percent chance the child will not inherit the defective gene.

CF carriers can be identified through a blood test or a sample taken from inside of the mouth. Often, if a person is suspected of having the disease a sweat test is performed. High levels of salt in conjunction with other symptoms may indicate a person has CF. In addition, prenatal DNA testing for CF can be done using the amniotic fluid or chorionic villi. (See “On the Web” for a list of CF resources.)

The nature of PBL

The development of PBL as an approach to instruction began in the medical school at McMaster University, Hamilton, Canada. Howard Barrows, a physician and medical examiner, developed and used the approach to better prepare students to work with patients (1996). Although traditional medical models of education help students develop a strong knowledge base, Barrows was concerned that traditional models fail to provide students with opportunities to integrate and apply knowledge in a clinical context. Barrows wanted students to “integrate, use, and reuse newly learned information in the context of patients’ problems” (Barrows 1985, p. 5).

Since its beginnings in medical school, PBL has been used in many other settings including law, nursing, forestry, business, and now, K–12 education. PBL is both a curriculum framework and an instructional approach that has the following characteristics:

- Students start the PBL process by being immersed in a real, ill-structured problem that has many possible solutions. Students assume a particular role in the problem (e.g., a doctor or counselor) simulating professionals in the field.
- Teachers become facilitators of learning, providing students with feedback and support as they explore the problem.
- Students work in collaborative groups, actively constructing their understanding of content and developing a range of inquiry skills as they explore the problem.

The adoption of PBL shifts the responsibility for learning from the teacher to the student and has the potential to foster interdisciplinary learning.
FIGURE 2

The CF problem.

This problem places students in two distinct roles—the role of a genetic counselor and the role of parents pregnant with a child afflicted with CF.

Part I:

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October 10, 2003

Ms. Diane Taylor
Counselor
Pediatric/Adult Services
Cystic Fibrosis Clinic
Saint John Hospital
P.O. Box 2100
Saint John, New Brunswick
E2L 4L2

Dear Ms. Taylor:

My husband and I are expecting our first child in late May. I am six weeks into the pregnancy. It is an unplanned pregnancy; however, we are thrilled, excited, and a little apprehensive about becoming new parents. One of our major concerns for our unborn child is related to cystic fibrosis (CF). My husband has a family history of CF and we want to find out about what the probability is that our unborn baby will have CF. We have many questions and concerns. We would like to learn more about CF and prenatal testing.

Would it be possible to set up a meeting to discuss these issues with you as soon as possible? My husband and I may be reached at 506-455-3404 or via e-mail at ghicks@hotmail.com.

We look forward to hearing from you in the very near future.

Sincerely,

Gail and John Hicks

Gail and John Hicks

Problem: Assume the role of Ms. Taylor, a genetic counselor. What advice would you give the Hicks couple in response to their request?

Part II:

Problem:

After undergoing prenatal testing, Gail and John are devastated by the news that their unborn child tested positive for CF. Pretend you are Gail and John. Should you continue the pregnancy? What do you need to know to make this decision?
Scaffolding chart outlining how one group of students defined the problem.

<table>
<thead>
<tr>
<th>Facts</th>
<th>Learning issues</th>
<th>The action plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mrs. Hicks is six weeks pregnant. The pregnancy is unplanned. Mr. Hicks has a family history of CF. They want to learn more about prenatal testing. We have to become genetic counselors and give the couple advice.</td>
<td>What is CF? How does someone get CF? What is a carrier? How does one know if you have the CF gene? What are the symptoms of CF? How is it inherited? How many people are at risk for CF? What is the role of a genetic counselor? Is there prenatal testing for CF?</td>
<td>Interview someone with CF. Talk to a parent of a child with CF. Use the library to find some information about CF.</td>
</tr>
</tbody>
</table>

Planning for PBL
To plan our PBL lesson, we first had to select a topic. The teacher with whom we collaborated in the high school biology classroom decided to use this opportunity to focus on a problem that would help students develop an understanding of the relationships among science, technology, and society. She felt this was an area of the curriculum she did not emphasize enough.

Consequently, we designed a PBL lesson that would allow students to demonstrate their understanding of the role of genetics counseling and gene testing in the identification and treatment of a genetic disease. In addition to using and developing a range of critical thinking, communication, and research skills, we wanted students to develop an appreciation of the ethical dilemmas that may arise from the application of scientific research and technological advancements in the field of genetics.

After deciding on an area of focus, we developed a two-part problem that placed students in two distinct roles—the role of genetic counselor and the role of parents pregnant with a child afflicted with CF (Figure 2, p. 23). Next, we brainstormed a list of questions students might ask about the problem, selected student resources to support the problem, and developed a timeline for implementation. We implemented the problem over an eight-week period for one hour per week. Students were placed in heterogeneous groups while participating in a variety of learning and assessment activities.

Implementing the PBL model
Throughout the implementation, the teacher served as facilitator. Before introducing the CF problem to students, we explained our rationale for using PBL and presented students with a simple post-hole problem to familiarize them with the PBL process. Post-holes are simple problems that follow the PBL structure but are designed to be completed in one or two sessions. In this instance, students were presented with a case history of a high school hockey player on anabolic steroids. Students were given fact sheets and asked to come up with ideas to persuade the student in question to give up using performance-enhancing drugs.

Meet and define the problem
After showing students a short seven-minute video on CF about a young child with the disease (the hook for the PBL), we presented students with part one (the role of the genetic counselor) of the ill-structured problem (Figure 2, p. 23). After reading the problem together as a group, the teacher asked each group of four students to complete a scaffolding chart. Figure 3 provides a sample of entries made by one group. Throughout the unit, groups were asked to visit the chart periodically to update information.

Gather information and resources
Because this was the students’ first experience using PBL, we made the process fairly structured. To explore the problem, students participated in a range of learning activities and completed several pieces of both group and individual assessments. For part one of the problem, students were expected to complete the following:

- View a video from a choice of three and present a one-page summary (individual);
- Listen to a guest speaker, a parent with a CF child, and complete a one-page reflection paper (individual);
- Review an article from an Internet source and submit a summary (individual);
Draft a letter to the Hicks couple (Figure 2, p. 23), responding to their request for advice (group); and
Present advice (e.g., PowerPoint presentation, skit) in a five- to ten-minute presentation to the whole class (group).

Determine and present a solution
After developing a greater understanding of CF, students presented their advice to the class. This allowed the
teacher to assess students’ understanding of the problem and to fill in gaps in their understanding of CF.

Follow the PBL cycle again
PBL experiences may or may not have several components. The problem we adopted introduced a second
sub-problem (the role of the parents) that shifted the focus of the original problem (Figure 2, p. 23). Students
were placed in a situation where they had to make a decision about whether they would proceed with the
pregnancy and to consider their options if they did not want to have a child with CF. At this point, students
were very familiar with the implications of caring for a child with the disease. Once again, we provided students with resources to
explore the issue of abortion, asked students to update the scaffolding chart (e.g., facts, learning issues, and
action plan), and arranged for the class to participate in a debate on the subject of abortion. Two students
prepared arguments to support the pro-choice side, while two students presented a case against abortion. The
remainder of the class was expected to ask one question of the debaters, summarize the arguments presented on
each side, and prepare a short personal statement outlining their beliefs about abortion.

Debrief the problem
In the final debriefing of the problem, each group was asked to reach a decision about continuation of the
pregnancy. Each group was given five minutes to share its decision and outline the rationale for this choice. Only one of the six groups decided to terminate the pregnancy. By being placed in this situation, students were able to experience, through simulation, the personal and societal implications of scientific and technological developments and how they require individuals to explore their personal values and beliefs in relation to the field of genetics.

Finding the time
The major challenge for the teacher was finding time in a content-bound curriculum to implement a student-centered approach. For all its acknowledged benefits, PBL is necessarily “messy” and more time-consuming than the lecture and note-taking method. In addition to acquiring a new way of learning, students also have to assume new responsibilities. For example, students need to stay focused on the task at hand, maintain group awareness of approaching deadlines, and assume both group and individual responsibilities for a number of products. These skills are only acquired over a period of time.

Despite the challenge, the teacher and students were enthusiastic about their experience with PBL. In fact, independently, the teacher is continuing to use the activity this semester with another biology class. Students welcomed it as a new way of learning in which they were actively involved in acquiring information, making decisions, and working as part of a group. We strongly encourage teachers to explore PBL as an instructional approach that has the potential to immerse students in learning science content and the nature of science.

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On the Web
The Cystic Fibrosis Foundation: www.cff.org
Cystic Fibrosis Research: www.cfrs.org/home.htm

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