


A PARTNERSHIP for

*Challenging students
to consider open-ended
problems involving
gene therapy*

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Joseph Le Doux

So many demands are placed on high school teachers today. We are expected to engage students in authentic hands-on, inquiry-based learning that hooks them on the excitement of cutting-edge science fields, develops their higher-order thinking skills, exposes them to modern lab techniques, arms them with an understanding of the science that affects their lives and should inform their decisions as adults, and covers state and national curriculum standards. Simple? Not really. But the right kind of professional development can help teachers meet these challenges.

Problem- Based Learning



For two summers, I took part in the Research Experience for Teachers (RET). Through this RET professional development partnership, I attained greater in-depth knowledge of molecular biology and virology, became more familiar with cutting-edge lab techniques that teach students important skills for college, and brought my summer research experience back to the classroom through a problem-based learning (PBL) gene therapy module.

Background on RET partnership

When most teachers hear the phrase “professional development,” skepticism clouds their faces. But research-based professional development can provide interesting experiences and valuable content knowledge. Though many teachers do participate in research, the National Science Education Standards suggest that more should. Professional Development Standard A states that a science teacher’s learning experiences must “involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding” (NRC 1996, p. 59).

The RET program, funded by the National Science Foundation, helps “facilitate professional development of K–12 teachers and community college faculty through strengthened partnerships between institutions of higher education and local school districts; and encourages researchers to build mutually rewarding partnerships with teachers” (NSF). The long-term goals of our partnership established through RET are to stimulate the development and use of educational techniques and materials that will inspire high school students to consider careers in science and engineering and to increase communication between high school and college educators.

For ten months of the year I am a high school biology teacher. For the other two months I am a research scientist, at least I have been for the past two summers when I have worked in the Le Doux Lab at Georgia Tech as part of the RET program. Research in the Le Doux Lab revolves around gene therapy, focusing on retrovirus and lentivirus-mediated gene delivery to cells and the effect of genetic modification on the fate of embryonic and adult stem cells. My participation in the RET program has enabled me to help establish a three-member partnership that includes Joseph Le Doux, an associate professor of biomedical engineering, Cindy Jung, a biomedical engineering graduate student, and me.

The first objective of our partnership was to develop curriculum materials to motivate secondary school students to learn the basic concepts of gene therapy, understand what this technology can and cannot do, and consider what its effect could ultimately be on their health.

Gene therapy is a rapidly emerging technology with

the potential to have a profound impact on medicine and society. It provides an excellent example of how today’s scientists and engineers must integrate principles from several disciplines (physics, chemistry, biology, and engineering) to solve problems. In addition, the excitement generated by gene therapy may inspire some otherwise disinterested students to consider a career in science or engineering.

My first order of business was to get up to speed on gene therapy and molecular biology techniques. I learned cell culturing techniques and the planning, calculations, and techniques involved in several experimental assays. During my first summer (2003), I conducted experiments that helped show that the half-life of lentiviruses was longer than a related family of viruses called oncogenic retroviruses. The following year (2004), my investigations focused on developing methods to modify the properties of viruses in novel ways that are expected to have future use in engineering viruses to target and genetically modify specific cell types for the treatment of diseases or to help create artificial organs.

These research experiences forced me to relearn how to approach experimental design when I know little about the problem. I now view experimental design as a creative process rather than the step-by-step method often taught in classrooms. I realized that I need to help my students learn about the scientific process rather than teach them the “scientific method.” It became clear to me that becoming an expert on an intriguing topic is the most effective way to learn important concepts and to be able to generalize those concepts.

Problem-based learning in high school

As I became more comfortable with the research, I began to think about how I could effectively bring what I had learned back to my classroom. Shortly after I arrived, Le Doux shared his vision for implementing PBL in the high school classroom. His department had been successful in modifying PBL—a technique commonly used in medical schools, for use in engineering and science courses. They found that PBL, by placing their students in situations that mimicked those faced by practitioners in the field—was an extremely effective way to teach students how to think like biomedical engineers and scientists.

I had previously been intrigued by the idea of PBL, and partnering with Le Doux and Jung provided me the opportunity to try it out. I decided to use the “Star Legacy” inquiry-based learning method developed by The Iris Center at Vanderbilt University (IRIS). In this method, students are presented with a problem or challenge and are asked to outline an approach for addressing the challenge based on their current knowledge of the subject. Once they establish a plan, students learn from experts, who share the approaches they would have taken had they been asked to address the challenge. Armed with

FIGURE 1**“What Genes Are You Wearing?” PBL module.**

Hook: Attention getter designed to activate prior knowledge and inspire further study. Students listen to a segment from a National Public Radio interview with a young woman living with cystic fibrosis and reflect on the following questions:

- ◆ How would you feel if this were you?
- ◆ How would you feel if this were your child?
- ◆ What are the risks and benefits of a lung transplant?

Challenge: Gives students ownership of their learning by guiding them to learn about gene therapy so they can make an informed decision. The scenario is as follows:

You are a 16-year-old who suffers from [insert disease here]. Recently your condition has been worsening and you have been spending an enormous amount of time in and out of the doctor’s office and hospital. You are tired of being sick and just want the opportunity to be a teenager. Your primary physician has recently suggested that you undergo gene therapy.

You have no idea what gene therapy is or how it works. Your doctor keeps stating that you are lucky because there is a new study starting within the month at your hospital to test a new form of gene therapy for your disease. The gene therapy is very experimental and still in the very early stages, and the outcome of the treatment is uncertain. You have a week to decide if you want to become a part of this study, but before you decide if you want to join the study you must do some research on the topic.

Generate ideas: Students join groups and work to solve the problem based on their preexisting knowledge by considering three questions.

- ◆ What do you know?

- ◆ What questions do you have?
- ◆ What questions will require further research?

Meet the experts: Experts discuss their point of view about how to approach the challenge. Students review two video clips that discuss important points to consider about gene therapy and the risks versus benefits of gene therapy.

Research and revise: Students conduct research to help them meet the challenge. Students complete questions about diseases and gene therapy. Students are provided with the instructions:

- ◆ List questions you have.
- ◆ Answer all questions.
- ◆ Share and compare with other group members.

Test your mettle: Students engage in a mini-challenge to evaluate what they have learned. Students are provided with a list of diseases and medical conditions such as cystic fibrosis, muscular dystrophy, Alzheimer’s disease, and others and asked to determine which would be appropriate for treatment by gene therapy.

- ◆ Students compare their answers to those of the experts and discuss why their answers may vary.
- ◆ Students do further research as necessary.

Go public: Students present and defend their solution in public:

- ◆ Individually, students decide with their parents or guardians if they will join the clinical trial.
- ◆ Groups reach a consensus in class.
- ◆ Groups defend their decision before the class.

this additional insight, students improve their plan and proceed to implement it.

Later students participate in exercises designed to determine how much they learned about the subject while tackling the challenge. Finally, they share their accomplishments with others inside and outside of the classroom. A key to the success of PBL is that the problem must be open ended and not strictly defined. This creates a situation much like what scientists and engineers face in the real world.

A gene therapy PBL exercise

I created the “What Genes Are You Wearing?” PBL module (Figure 1) in which students are faced with the following challenge: “You have a disease and have been given the opportunity to join a gene therapy clinical trial. You must decide whether or not to participate in the trial.” The module began with a “hook” to excite students’ interest—they listened to a previously recorded National

Public Radio interview of a young cystic fibrosis patient to give them perspective on what it is like to be a teenager afflicted with an incurable disease (Rothenberg 2002).

Students then entered the “challenge” phase of the PBL problem. I presented them with a scenario in which each of them suffered from a serious genetic disease with no viable medical treatment. Each had been offered the opportunity to participate in a gene therapy clinical trial for their particular disease. Students then needed to decide whether or not to join the clinical trial and to back up their decision with facts about gene therapy.

To help students get started on their research, we had them “meet the experts” by watching a film in which Le Doux and another gene therapy expert, Peter Thule (Atlanta VA Medical Center and Emory University School of Medicine), discussed some of the key issues they would consider if deciding whether or not to join a clinical trial. My students then began to “research and revise” their decision, becoming gene therapy experts in the process.

After students had developed some expertise in gene therapy, I “tested their mettle” by asking them to comment on whether or not gene therapy was justified for a number of diseases and conditions, including baldness, familial hypercholesterolemia, cancer, and heart disease. To evaluate the soundness of their judgment, as a class we compared student decisions to the opinions of the experts.

Finally, students discussed their findings with their parents or guardians, further disseminating information about gene therapy to the public. Students reached a decision with their parents or guardians and then shared and justified their decision to their classmates in the “go public” portion of the PBL exercise. Each of these steps can be supplemented with alternative activities from various websites including the “Genetic Science Learning Series” at <http://gslc.genetics.utah.edu/units/genetherapy>. For example, students can investigate current clinical trials at <http://clinicaltrials.gov>, where they will find regularly updated infor-

mation about clinical research in gene therapy and other research in human volunteers. A valuable reference to the genetic disorders and gene therapy can be investigated at <http://ghr.nlm.nih.gov>.

Just the beginning

It is important to note that PBL can be used with students of virtually any age and skill level because it does not require students to learn one specific set of facts. Rather, PBL encourages students to make explicit their thought processes as they work through problems, helps them improve their problem-solving skills, and by its very nature engages students at a level appropriate for their current age and degree of knowledge. I used the gene therapy PBL module in my general level classes with little modification and with great success.

Before implementing the PBL module in my classes, I gave the students a pretest (Figure 2) that asked them

FIGURE 2

To gauge student learning, students received a pre- and posttest consisting of the same five questions:

1. Do you know what a genetic disease is? Give a definition.
2. Give an example of a genetic disease.
3. Do you know what gene therapy is? Give a definition.
4. Name a disease that can potentially be treated using gene therapy.
5. Do you know what genetic engineering is? Give a definition.

Students who answered “Yes” and could give a correct answer were put in the “Yes” category, while students who said “Yes” but could not give a correct definition or example were put in the “Not Sure” category. Students who answered “No” were put in the “No” category.

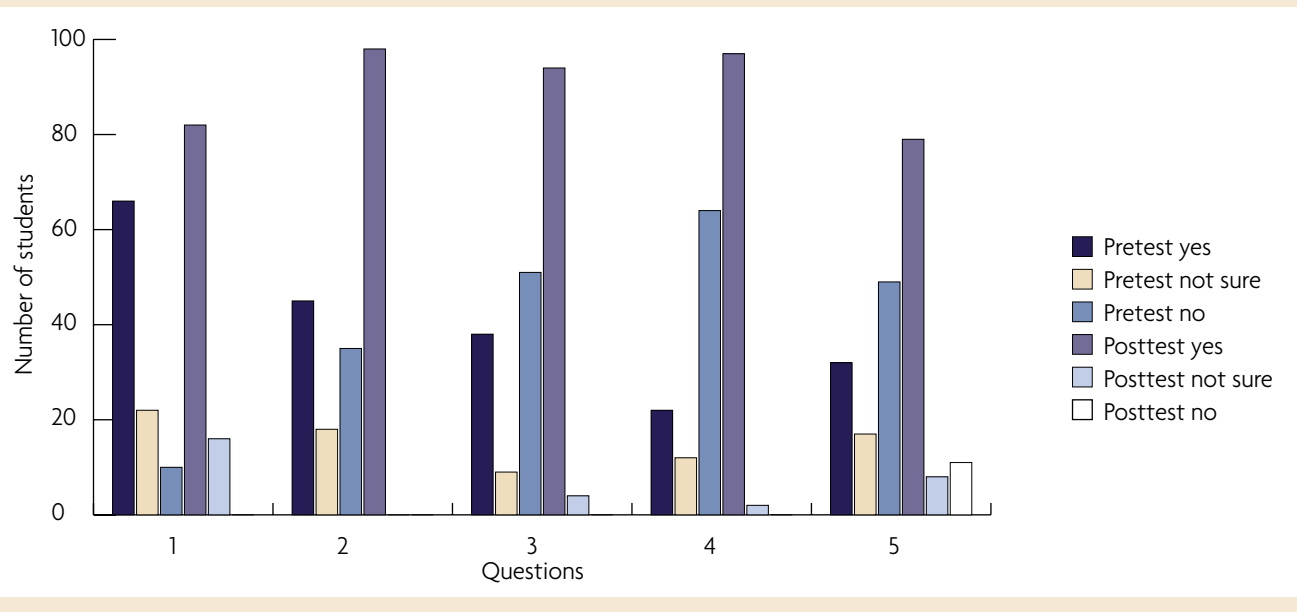
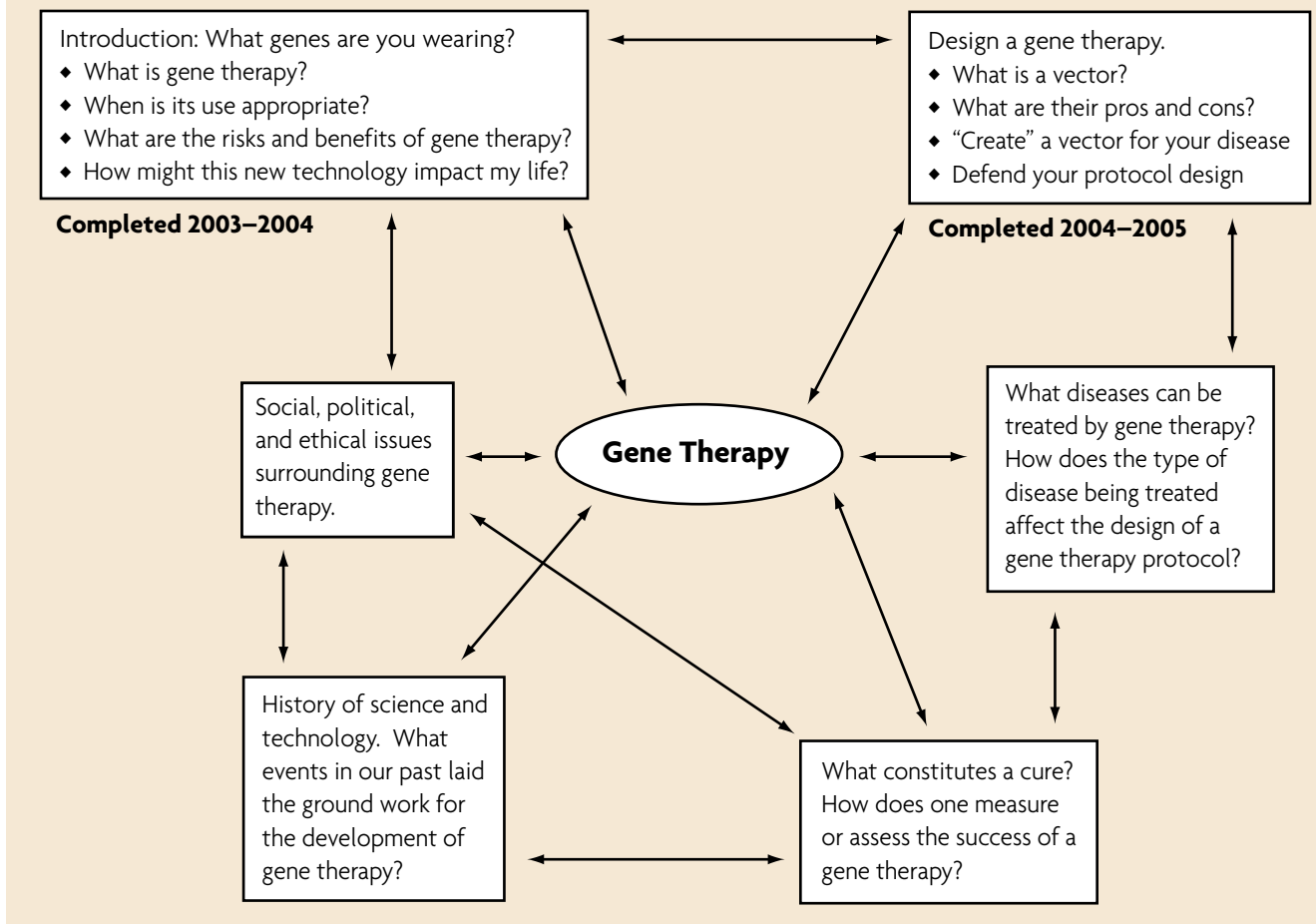


FIGURE 3

PBL modules designed to introduce high school science students to gene therapy.



basic questions, such as, “Do you know what gene therapy is?” If they answered “Yes,” I asked them to give me a definition. Only 35 of 97 students knew what gene therapy was and could give an appropriate definition. After completing the PBL module, 93 of 97 students gave an excellent explanation of what gene therapy is and were able to name a disease for which gene therapy is currently being considered as a treatment.

I plan to develop and seek additional PBL modules and share them with my colleagues (Figure 3). My partners and I have already completed a second PBL module designed to teach students about virus infection and virus structure, and we plan to post all of our PBL lesson plans, including the video of Le Doux and Thule, on the internet (see www.bme.gatech.edu/groups/ledoux/ for a link to these materials).

Thanks to my RET experience, I have a better understanding of gene therapy and how gene therapy research is done in the university laboratory setting, and I have an enhanced understanding of laboratory techniques and experimental design, which I have already brought back to my classroom. In addition, I now have contacts

that I can turn to for help with questions that will undoubtedly arise in a classroom where students are challenged to consider open-ended problems and plan how to move toward sound solutions. ■

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