Piquing Student Interest with Pharmacology

An interdisciplinary program helps high school students learn biology and chemistry principles

— **Myra J. Halpin, Leanne Hoeffler, and Rochelle D. Schwartz-Bloom**

Motivating high school students to learn basic biology and chemistry concepts is an ongoing challenge. Although there is a paucity of research on specific topics of interest to students, topics considered to be inherently interesting include death, danger, disease, injury, sex, and romance (Shank 1979). Because high school students in the United States score below their international peers in science and math (NCES 1998), secondary science teachers are under pressure to make science courses interesting and relevant to today's youth. Teaching practices and topics that arouse student interest can help motivate students to learn and increase achievement (Sandoval 1995).

To help students learn science concepts, we developed the Pharmacology Education Partnership (PEP)—a science education program that incorporates relevant topics related to drugs and drug abuse into standard biology and chemistry curricula. The interdisciplinary PEP curriculum provides six modules to teach biology and chemistry principles within the context of pharmacology topics (e.g., drugs of abuse, nerve gas); it is available at no cost to teachers at *www.thepepproject.net*. Teaching modules include catchy names, such as "Acids, Bases, and Cocaine Addicts," "Steroids and Athletes: Genes Work Overtime," and "How Do Drugs Damage Neurons: It's Radical!" (Figure 1). A national study has shown that students using the modules performed significantly better on biology and chemistry tests when compared to a control group (Schwartz-Bloom and Halpin 2003). The PEP curriculum meets the requirements of the National Science Education Standards (NRC 1996) and the Project 2061 Benchmarks for Science Literacy (AAAS 1993).

Field-testing the curriculum

During field-testing of the PEP curriculum in the high school classroom, teachers nationwide participated in our randomized controlled study. We provided a one-week professional development workshop so teachers could learn basic pharmacology principles and learn how to integrate the PEP modules into their biology and chemistry teaching. Following the workshop, teachers used the PEP content in their classes over the next year; there was no specific method prescribed—teachers used the modules in a way that fit their teaching style and curriculum. At the end of the year, the teachers administered a short test (unannounced) of the basic concepts in biology and chemistry as well as some advanced concepts on drugs.

The results of the testing (3,800 students) are shown in Figure 2 and have been published (Schwartz-Bloom and Halpin 2003). When at least two modules were used, students scored significantly higher on biology and chemistry questions compared to students using the standard curriculum. Additionally, student performance in classes whose teachers attended the workshop was significantly better than that in classes whose teachers did not attend the workshop.

A second PEP study is underway; we developed two additional modules and reduced the professional development to either a six-hour workshop at the National Science Teachers Association or North Carolina Science Teachers meetings or at a distance-learning workshop (two hours/week for three weeks). These teachers have just completed their field-testing, and data from approximately 12,000 students are being analyzed.

The PEP modules

Each of the PEP modules focuses on a pharmacological topic that integrates biological and chemical principles (Figure 1). The modules also integrate other subjects appropriate to the topic, such as mathematics, public policy,

FIGURE 1

The PEP modules.

Module title	Module content
1. Acids, Bases, and Cocaine Addicts	acid-base chemistry, molecular structure, circulatory system, membrane transport, cocaine formulations, addiction biology
2. Drug Testing: A Hair-Brained Idea	acid-base chemistry, molecular structure, cellular structure, anatomy, biology and chemistry of hair, nicotine, cocaine, heroin, ethics of drug testing in hair
3. How Do Drugs Damage Neurons: It's Radical!	oxidation-reduction, oxygen radicals, neuron structure, neurochemistry, cell death, methamphetamine, neurodegenerative diseases
4. Military Pharmacology: It Takes Nerves	covalent bonding, enzyme action, autonomic nervous system, physiology, behavior of gases, chemical warfare, Middle East and Japan current events/history
5. Why Plants Make Drugs for Humans	plant cell structure, acid-base chemistry, molecular structure, membrane transport, tobacco industry economics
6. Steroids and Athletes: Genes Work Overtime	chemistry of testosterone, molecular structure, muscle cell anatomy and physiology, DNA structure, transcription and protein synthesis, androgenic/anabolic steroids, drug testing

psychology, and social sciences. The content in each pharmacology module includes

- a set of learning objectives,
- an inquiry-directed student handout (problem-based learning approach),
- a teacher's guide with background science content (containing answers to student questions) and illustrative graphics,
- a glossary of terms,
- a resource list, and
- student hands-on or "minds-on" activities and assessment strategies (developed by teachers at the workshops and added to the modules).

The modules are designed so teachers can incorporate them into their standard curriculum to fit their teaching style and time constraints. These modules are not additions to the curriculum but supplements to allow teachers alternate, enhanced ways of teaching concepts in

FIGURE 2

Performance of all students on questions of "basic knowledge" and "advanced knowledge" depending on the number of modules used during the course.

Data are the mean ± S.E.M. scores from biology and chemistry students in basic and advanced classes. Hierarchical linear modeling (HLM) revealed that the number of modules was a significant predictor of student scores (Schwartz-Bloom and Halpin 2003).

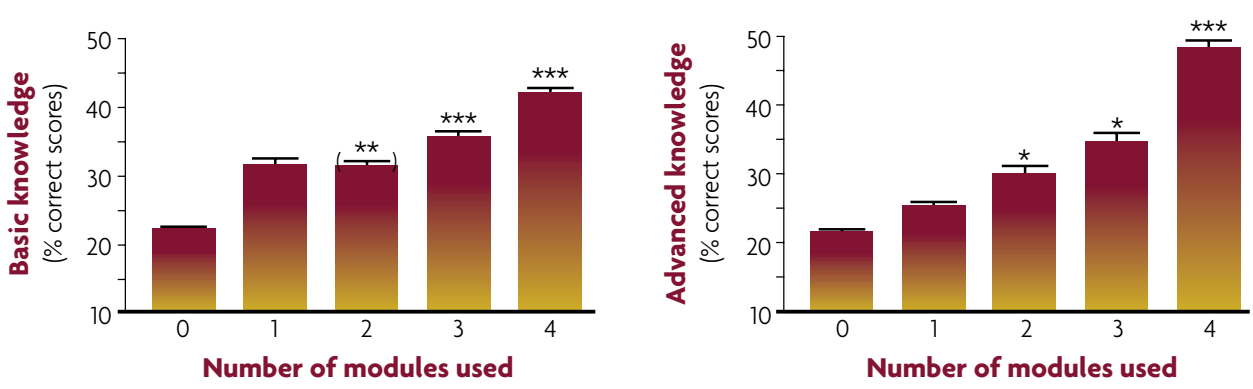

FIGURE 3

A sample page from the PEP website.

The science content for Module 3 ("How Do Drugs Damage Neurons? It's Radical!") is on the left panel, and a figure that accompanies the text is on the right panel. This particular figure is animated; the user clicks on the thumbnail and the animation starts automatically.

FIGURE 4

An example from the student handout in Module 6, "Steroids and Athletes: Genes Work Overtime."

.....Once in the nucleus, the steroid receptor complex comes into contact with the DNA. The steroid receptor binds to a specific site on the DNA molecule, causing the DNA to start the process of gene transcription. This leads to the synthesis of certain proteins, depending on the cell-type and the part of the DNA to which the steroid receptor complex binds. All of these events take time, and a sustained use of the steroid is required to continually instruct the genes to synthesize more protein.

- What kind of molecule is DNA? Describe its essential features.
- What is gene transcription?
- How is the protein synthesized?

the existing curriculum. Concepts in chemistry include acids and bases, solubility, and oxidation/reduction. Concepts in biology include membrane transport, the circulatory system, and the nervous system. Another advantage of the modules is that biology students learned some chemistry and chemistry students learned more biology than their peers who used the standard curriculum (Schwartz-Bloom and Halpin 2003). Most notably, students appeared to relate material that they learned from two different courses. This demonstrates the positive impact of an interdisciplinary approach to teaching biology and chemistry.

The PEP website

The PEP website for teachers and students is one of the highlights of the project. Its high-quality graphics and animations combined with the interactive nature of the various components make it a unique, fun educational tool. Figure 3 illustrates an example of a page from the PEP website. The modules can also be downloaded for teachers to use offline; each file can be saved in PDF format. Other features include a pop-up glossary and a "What Did I Learn" section for students in which they engage in interactive quizzes that assess content knowledge for each of the modules.

PEP and inquiry-based learning

Each PEP module contains an inquiry-based "Student Handout." A series of instructive paragraphs for each topic is presented, with several questions that students must answer on their own. The teachers have access to the answers in the "Content Background" section. Several teachers who field-tested the modules wanted their students to have access to the content background, which is possible within the website itself; however, this may lessen the integrity of the inquiry-based approach or make this a limited inquiry activity because students are given the material to read. An example from the student handout in Module 6, "Steroids and athletes: Genes work overtime," appears in Figure 4.

A second feature in the PEP curriculum that addresses inquiry-based learning is provided in the "Classroom Activities." These activities were developed by teachers who field-tested the PEP curriculum. Some activities are inquiry-based, some are more traditional lab "hands-on" activities, and some are "minds-on" activities that do not involve a lab experience.

The PEP curriculum and the Standards.

To help teachers identify how the module content addresses the National Science Education Standards (NRC 1996), each module lists the specific science content and assessment standards that are relevant to the content contained within the module (within the "Teacher Notes" section). On the PEP website at *www.thepepproject.net*, this is indicated with a series of interactive "buttons" that are coded for the appropriate standards contained within the module. A teacher can click on a button to read about the science content or assessment standard appropriate to the module.

Improving performance with modules

PEP is an interdisciplinary approach to help high school students learn biology and chemistry concepts. To date, PEP has provided professional development for 300 biology and chemistry teachers participating in the studies (and another 100 teachers at ongoing workshops). National field-testing of the curriculum in approximately 16,000 students reveals that the more PEP modules the teachers use, the better their students perform on tests of biology and chemistry concepts. An additional benefit of this approach might also help students make intelligent decisions about drug use, although this remains to be tested. Substantial gains in achievement may be possible when high school students are taught science using topics that are interesting and relevant to their lives. ■

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