The Pharmacology Education Partnership: Improving High School Biology and Chemistry

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Introduction

The Pharmacology Education Partnership (PEP) is a curriculum we developed for high school biology and chemistry teachers, providing them with tools to teach biology and chemistry principles using pharmacology topics (e.g., drugs of abuse). This partnership between Duke University Medical Center and the North Carolina School of Science and Math (NCSSM) was funded by a Science Education Drug Abuse Partnership Award from the National Institute on Drug Abuse. The major premise of our project was that high school students might learn basic concepts in biology and chemistry better if the material was presented in the context of something interesting and relevant to their own lives. Forty-seven teachers across the US were trained to use the curriculum in their classrooms (a second project is ongoing with ~220 teachers being trained across the US). The PEP project includes several components such as curriculum design, science content, and professional development. The PEP project has been tested in 3500 students nationally and has demonstrated significant achievement in high school biology and chemistry in those classrooms using the PEP modules. The results of the study were published in the Journal of Research in Science Teaching (Schwartz-Bloom and Halpin, 2003). Below, several of the features and our findings are summarized.

The PEP Modules

Initially, we developed four pharmacology modules that were field-tested by 47 teachers throughout the US. [In our ongoing project, we have developed two additional modules.] The current curriculum involving all six modules is online at www.thepepproject.net and is available to the public. Briefly, each module focused on a pharmacologic topic that integrates biological and chemical principles. The modules also integrated other subjects appropriate to the topic, such as mathematics, public policy, psychology, and social sciences. Each pharmacology module consisted of 1) a set of learning objectives, 2) an inquiry-directed student handout (problem-based learning approach), 3) a teacher's guide with background science content (containing answers to student questions) and illustrative graphics, 4) a glossary of terms, 5) a resource list, and 6) student hands-on or "minds-on" activities and assessment strategies (these were developed by the teachers at the workshop and then they were added to the modules).

The six modules developed for the PEP curriculum are summarized in Table 1 (below).

PEP Curriculum Modules

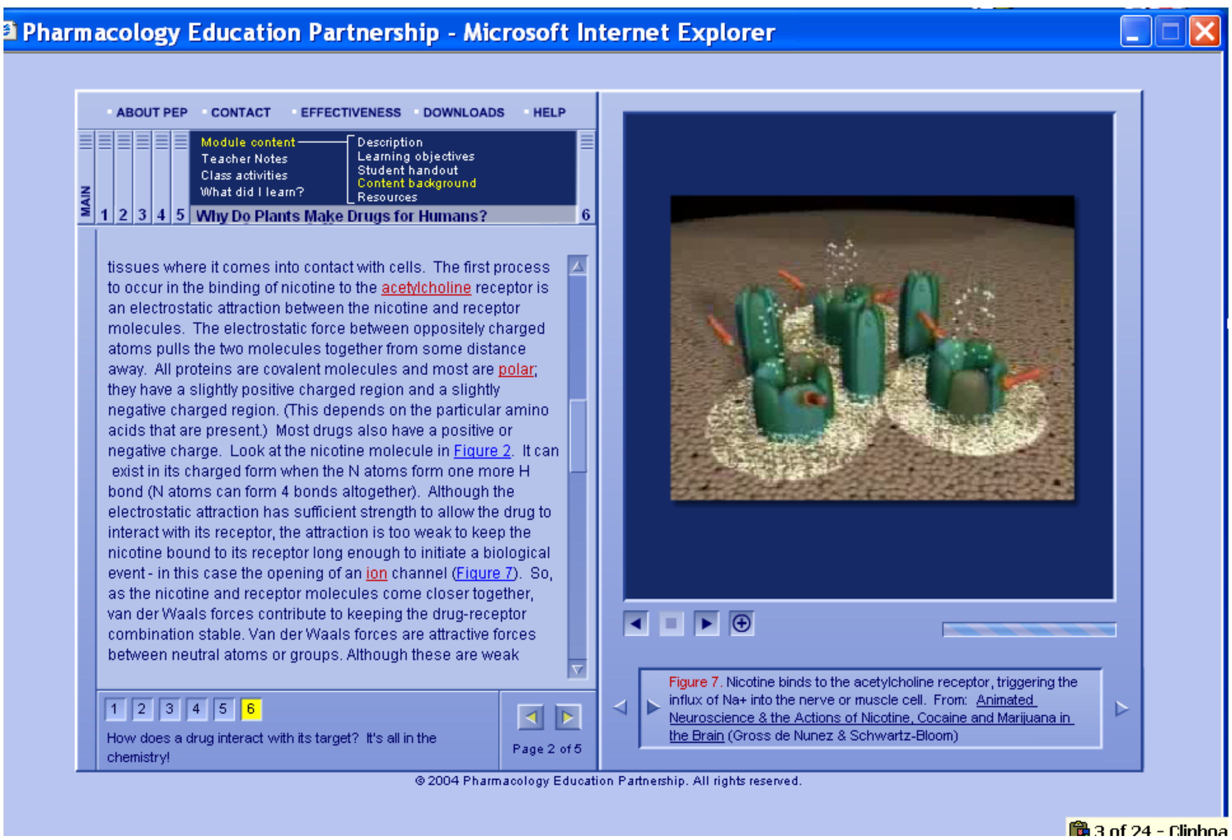
Module Title	Module Content
1. Acids, Bases, and Cocaine Addicts	acid-base chemistry, molecular structure, circulatory system, membrane transport, cocaine formulations, addiction biology
2. Drug Testing: A Hair-Brained Idea	acid-base chemistry, molecular structure, cellular structure, anatomy, biology & chemistry of hair, nicotine, cocaine, heroin, racial ethics
3. How Drugs Kill 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 & Japan current events/history
5. Why Plants Make Drugs for Humans	plant cell structure, acid-base chemistry, molecular structure, membrane transport, tobacco industry chemical "tricks"
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

The PEP modules were designed as supplements to provide teachers with alternate ways of teaching basic concepts already covered in their existing curricula. There is no prescribed method for using the modules, thus providing the flexibility that teachers need so that they can incorporate the content in a way that fits their own teaching styles and time constraints.

The PEP Website

The six modules can be found online at our website, www.thepepproject.net. 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 and fun educational tool. An example of one of the screens from the PEP website is shown in Figure 1. The science content for Module 5 ("Why Do Plants Make Drugs for Humans") is on the left panel, and a figure that accompanies the text is on the right panel. This particular figure is animated on the website; the user clicks on the thumbnail image and the animation starts automatically. The animation shows how acetylcholine and nicotine bind to an acetylcholine receptor to open sodium channels and produce a current across the membrane. Other features in the PEP website include a pop-up glossary and a section for students called, "What Did I Learn?" In this section, students engage in interactive quizzes that assess content knowledge for each of the modules.

Figure 1



Professional Development: The Workshops

The 47 teachers recruited to participate in the PEP project attended a one week professional development workshop at Duke University. We used a "wait-listed" control design; 22 teachers attended the workshop and field-tested the modules the following year; the second year, the remaining 25 teachers attended the workshop ("wait-listed" controls) and then field-tested the following year. During the workshop, teachers learned basic pharmacology principles that apply to biology and chemistry concepts. Also teachers worked in groups to develop supplemental classroom activities (both inquiry-based and non-inquiry based) for each module. Using a pretest/posttest design, we found that teacher knowledge of biology and chemistry concepts (20 true/false questions) increased at the end of the 1 week workshop (as expected) and was maintained for at least one year (Figure 2). In our ongoing project, the professional development includes the same instruction in a full day workshop at the National or North Carolina Science Teachers Association meetings or in a Distance Learning workshop over 3 weeks—data from the 220 teachers participating supports our previous findings; teachers' knowledge increased at the end of the one-day or the Distance Learning workshops and as before, knowledge was retained throughout the school year.

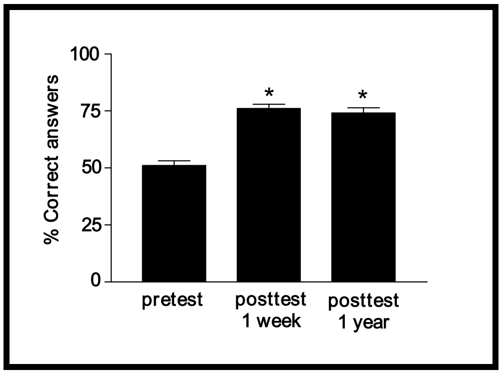


Figure 2

The professional development is an important component of the PEP curriculum. Analysis of the data revealed that student performance in biology and chemistry classes whose teachers attended the workshop was significantly better than that in classes whose teachers did not attend the workshop (Schwartz-Bloom and Halpin, 2003).

Field-testing the Curriculum

At the workshops, the teachers were instructed to incorporate the modules into their standard curriculum in a way that fit their own teaching styles and time constraints. Teachers field-tested the modules in their classrooms of beginning or advanced biology or chemistry—all four years were represented. At the end of the school year, we tracked the number of modules used by each teacher. Six of 47 teachers did not use any modules, and of those who did use modules, 28 used more than one module. In our ongoing project, we tracked the online usage of the modules by both teachers and students online; for the 2003-2004 school-year, we have had hundreds to thousands of hits on each module by both teachers and students.

Evaluation of the Curriculum

At the end of the year of field-testing, students (~3500 total, from both the control and experimental groups) were administered a 20-item multiple choice test of basic biology and chemistry principles ("basic knowledge") and an 8-item test of their knowledge about drugs ("advanced knowledge"). Statistical analysis of the data collected using hierarchical linear modeling revealed that the use of the PEP modules was a significant predictor of better performance in both biology and chemistry classes compared to standard curricula in which no modules were used (Schwartz-Bloom and Halpin, 2003). The more modules used, the better the students performed (i.e., a "dose-response" effect) in both the basic and advanced knowledge categories (Figure 3); there were gains of up to 28 percentage points when 4 modules were used compared to no modules. Other predictors of improved scores included the course level (i.e., advanced placement) and course type (i.e., chemistry vs biology). The student year ($9^{th}/10^{th}$ vs $11^{th}/12^{th}$ grades) did not predict better scores. The degree of improvement obtained by using the modules is considerably greater than that reported in several science education studies of standards-based instructional practices (Von Secker and Lissitz, 1999; Kahle et al., 2000). We are in the process of analyzing data from our current study from ~13,000 students across the US.

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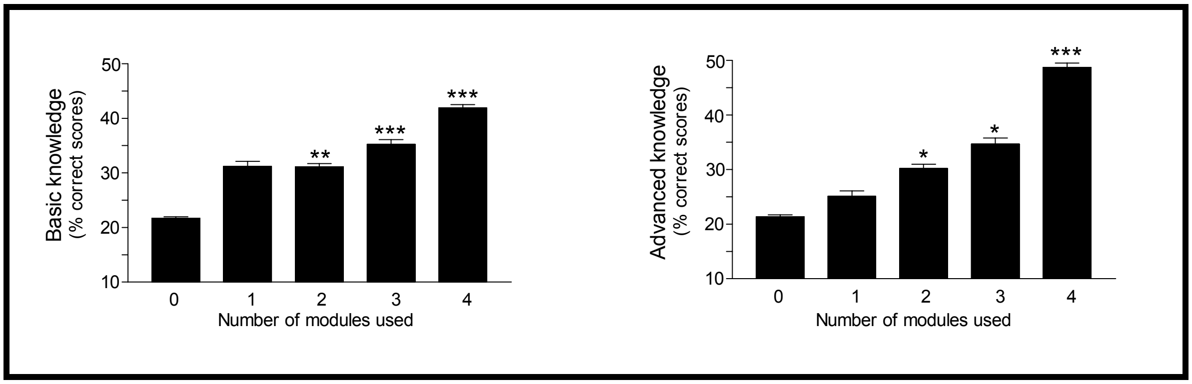

Figure 3

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)

In addition, we found that biology students increased performance on the chemistry questions, and chemistry students increased performance on biology questions when at least two modules were used. The findings supported our hypothesis that not only would biology students learn biology better, but they also learned chemistry better (and vice versa).

Conclusions

The substantial gains in biology classes on chemistry questions, and vice versa, highlights the usefulness of pharmacology topics, which have an inherently integrative nature, in science education. In addition, the real-world relevance of the content in the modules may have been a major factor in the successful outcome of this study. Topics on drugs and drug abuse are probably highly relevant and meaningful to high school students. If such topics can help capture student interest in science, then other features of science education reform may be more effective. One of the ultimate goals in science education is to help students use science to be critical thinkers and make good decisions in their daily lives (Yiping, 1996). It remains to be determined whether a program such as the one we developed will help teenagers make intelligent decisions about drug use. Nevertheless, the approach we have taken using pharmacology topics should be applicable to many areas of science that are parts of students' daily lives.

References

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