Effective Use of a Range of Authentic Assessments in a Web Assisted Pharmacology Course

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ABSTRACT
Building upon previous research on teaching science at the college level, an Introductory Pharmacology course was designed in a problem-based learning environment, using cooperative learning pedagogies, case studies, and integrating technology into every class period. Teaching pharmacology through a case studies and problem-based approach is beneficial to understanding the societal impact of drugs, as well as grasping an understanding of the mechanisms of drug action, the parameters for dosing and the general categories of therapeutic medicines and drugs of abuse. Pairing a strong content in class with an adjunct online environment created an opportunity for students to discuss their newly found perspectives on pharmaceuticals within an online learning community. Each case study introduced a problem in pharmacology that students solved by integrating information from reading assignments, in class “graphic lectures” and “thinking activities” as well their own self-directed learning and collaborative group problem solving sessions. In addition, students discussed drugs and pharmaceutical concepts through the online bulletin board and chat rooms. For extra credit, students took online quizzes focusing on drug categories not specifically covered in class. The final technology-based project in the course was a authentic society based investigation of Pharmaceutical Concoctions. Multiple assessments provided data in content, process-oriented and outcome-oriented contexts. Data from the online components (bulletin board, chat, email and the extra credit quizzes) in addition to in class assessments, created the opportunity for the instructor to develop an evaluation profile for each student in the course. Upon analysis by a qualitative rubric, the bulletin board postings demonstrated a progression in the “knowledge to application “ conversion of science and pharmaceutical concepts.

Keywords
Problem-based learning, Online evaluation, Case study, Pharmacology, Authentic assessment

Introduction
Evaluation in science courses has typically focused on content from traditional in-class assessments. The online environment offers an extension of the science classroom in manners not previously possible. Instructors wanting to incorporate new learning technologies into science courses are sometimes hesitant to replace pen and paper exams with performance-based assessments, but many of the new strategies are best evaluated by more authentic representations of student work. In order to investigate alternative methods of assessment, an Introductory Pharmacology course was designed in a problem-based learning environment, using cooperative learning pedagogies, case studies and integrating the technology into every class period. Teaching pharmacology through a case studies and problem-based approach is beneficial to understanding the societal impact of drugs, as well as grasping an understanding of the mechanisms of drug action, the parameters for dosing and the general categories of therapeutic medicines and drugs of abuse. Pairing a strong content in class with an adjunct online environment (see Figure 1) created an opportunity for students to discuss their newly found perspectives on pharmaceuticals with an online learning community.

The Students on the Course
An interesting aspect of the course is that it was designed for science teachers. Teachers often encounter questions about drugs in their classrooms. This course offered a holistic approach to understanding drugs in our society and in our schools. Some science teachers must teach a section of the curriculum dealing with drugs of abuse. Teachers of anatomy and physiology also mention drugs when discussing certain diseases. The pharmacology concepts of absorption and distribution of drugs may be beneficial to incorporate in all biology curricula. Many students in schools are taking prescribed medications. Knowledge of the side effects, dosing,
and nutritional considerations of these drugs is important to understanding the students’ actions and capabilities. Teachers generally have not had formal coursework in these areas and this course filled a need for content knowledge that may be applied to both the science teaching curriculum and assisting and understanding students and their personal needs. Thus the evaluation component of the course held greater importance when understanding the eventual numbers of students the content could reach.

Figure 1: Introduction to Pharmacology Homepage

Integration of the Learning Environment with Course Objectives/Learner Outcomes

Building upon previous research on teaching science effectively at the college level, the course was designed in a problem-based learning environment (West, 1992) using case studies (Herreid, 1993, 1997), cooperative learning pedagogies (Foster, 1996; Klionsky, 1997), and integrating multimedia technology (Neo & Neo, 200; Trowbridge & Wandersee, 1996; Moore & Miller, 1995) into every class period.

Problem-based learning (PBL) was first recorded in medical education in the early 1970’s, although the problem-based approach has been a part of medical and pharmaceutical education for centuries in the form of the apprentice model. An apprentice not only learned the content and skills of the job, but assisted his mentor in working through many long term projects of knowledge application, especially during the burgeoning eras of chemistry in the 17 and 1800’s. In problem-based learning, students are active learners. Several authors (Gallagher, 1997; Savery and Duffy, 1996) have described the learning process in problem-based environments. All students work in small cooperative groups on the same problem presented by the teacher. The problem presented to students in PBL helps students to activate their prior knowledge and to discuss with others the new information in a manner that will reconstruct their concepts in order to solve the problem. Based on the epistemology of constructivism, the problem in a problem-based learning experience works as a stimulus for authentic activity.

According to Hsu (1999), the problem-based process may be described in seven steps. The students internalize and reason through the problem the teacher has assigned them in order to 1.) define the problem and identify the learning issues, 2.) frame the learning objectives, 3.) determine the tasks to be undertaken and assign a work schedule to each member, 4.) gather the data on their own, utilizing in course and outside resources, 5.) present and discuss learning findings with the group, 6.) synthesize and summarize findings into solutions, and 7.) justify their solution by conducting an assessment to see if all of the objectives have been satisfied. Finally, they receive feedback from the instructor. The intended gains include metacognition skills, self-directed learning skills, critical thinking and problem-solving skills, knowledge acquisition, retention, and use, collaborative learning and higher motivation and positive attitude.

The PBL approach fosters students’ multiple skills and allows them to acquire knowledge in the process of solving a problem, as well as the opportunity to place teacher-transmitted factual information in a coherent and connected position in the concept schema. This is opposed to the traditional approach in which the content is delivered in a teacher-centered lecture where much emphasis is placed on memorization, and not enough on developing thinking skills. While working through a problem in PBL, students are collectively evaluating what
they know, and personally evaluating what they still need to know better or understand in a different way. Duffy and Cunningham (1996) consider assessment to be ongoing and thus cannot be separated from the learning process. Assessment in PBL is occurring at two levels; the students are evaluating their strengths and weaknesses throughout the problem-solving experience, while the teacher has the opportunity to evaluate the students’ learning process. Brooks and Brooks (1993) suggest teachers evaluate students through interactive teaching, observing students working with ideas and materials and asking questions that challenge students to assess themselves. In order to promote learning, ongoing and timely feedback provides students with appropriate “mile markers” in their learning progress (Wiggins, 1998).

In designing this course, I was cognizant of the fact that the students would not be pharmacy or medical students. In many cases, the students in this course would be encountering the concepts and terminology for the first time. My goal was truly more learner-outcome based, than a teacher-directed objective. I wanted students to make gains in critical thinking and problem solving in pharmacology in order to assess the validity of many medicinal issues in our society and in their schools. This required a basic knowledge of some pharmacological concepts in order to have a knowledge base from which to explore and evaluate outside resources. In this context, emphasis was placed on content as a building block for their subsequent self-learning experiences, and thus students obtained some learning outcomes to a deeper level than others during the course. Thus, it was more important for me to observe a gain in knowledge than the traditional summative evaluations usually accompanying courses in science, although basic concepts were still assessed.

The problem-based approach afforded me the opportunity to assess students on an ongoing basis and then provide feedback in appropriate and timely constructs. The problems were designed as case-studies in the traditional medical format, but the feedback was provided in the form of “graphic lectures” and “thinking activities”. I describe here the assessments and activities in the class, and later categorize the assessments in a scheme of evaluation.

The Case Study

Real-world problems are sometimes open-ended and have no clear-cut answer. At times it takes a team approach to solve such problems, and the solutions may require specialized knowledge that is not immediately at hand. In this course, a category of drugs was introduced by a case study of a disease that has societal implications or concerns. Through the study of the etiology of the disease, the significance of the disease and the major drugs used to treat the disease, the student develops a concept of drug action, pharmacological mechanisms, structure/activity relationships, and dosing considerations.

The course began with a presentation of a patient chart to each cooperative group of students. The case described a patient’s physical history and current state and the problem the students must solve. Students were given no feedback during this initial phase of prior knowledge acquisition and cooperative group identification of key points. After 30 minutes of discussion, the groups were asked to write a solution for their patient’s dilemma based on what they collectively know, infer or suppose. These solutions were collected after each group presented their ideas to the class as a whole. I then began to conduct the class with graphic lectures and hands-on activities that incorporated their ideas and introduced basic concepts needed to solve the problem. After each class period, the groups revisited their initial hypothesis and developed a revised solution based on their new knowledge constructs. As became necessary, groups assigned tasks in order to research more about concepts presented in class. Occasionally, solutions derived at the end of class were revised out of class time when students were involved in self-directed learning. The next meeting of the group necessitated the inclusion of these self-learned concepts as “teaching moments” for the rest of the group. At the end of the case study, when all basic information had been uncovered by either lecture or activities, each group proposed their answer to their peers and the instructor in an organized and informed manner.

There were three cases covered as problem-based learning experiences in this semester course. The Guinea Case first introduced pharmacological principles of dosing and kinetics, absorption, distribution and elimination (see Figure 2). In the Case of Albert, students contemplated problems about alcoholism and drugs of abuse. This second case introduced concepts of enzymes, interactions, neuroregulation, inhibition, stimulation, replacement and depletion. In the third case, The Case of Melanie, the topic was anorexia and the use of diuretics, anxiolytics and antidepressants. In this case, the concepts of acid/base chemistry of elimination, alternative medicines, adverse reactions, and the nutritional balance were introduced. The Guinea Case was revisited at subsequent times during the semester, as more information about dosing and kinetics of drugs was introduced during the
other cases, and students reevaluated their prior conceptions. The Case Studies are included at the end of this paper.

Figure 2: The Guinea Case Patient Chart

"Graphic Lectures"

Many lectures in science courses are teacher-directed and involve students passively taking notes, most of which could have been given to the student without teacher explanation or enhancement. As an instructor who passionately believes in knowledge construction as an active component, I organized the class periods to incorporate time for students to reflect on their knowledge, to share their knowledge and to problem solve. In an effort to make content alive, I utilized a self-designed website that contains online animations accessed during specific times when visual representations would benefit students' understanding. In addition, students worked from graphic organizers (visual component to lecture material) as we moved through information that was essential to solving the case study problems. Students added information to their previously downloaded and printed graphic organizer (see Figure 3) for that lecture day. In class, I accessed the online glossary to define pharmacology terms as well as links to other websites and chemical databases both when I had planned an explanation or when students asked for a definition. I used a combination of online visual aides and the real time completion of the graphic organizer on an overhead throughout the lecture.

The lecture mode was nonstandard, in that I used a combination of strategies that imposed student collaboration and assimilation of knowledge in between “lecture” components. A 10-2 strategy was beneficial for creating a learning environment where students know they will have an opportunity to evaluate what they understand during class. For every 10 minutes of lecture, I stopped for 2 minutes in order to allow students to pair-share and compose a next-question, or pair-share and compose a statement of concept knowledge up to that point. I randomly chose pairs of students to present their next-question or concept statement. In addition, during the 10 minute pieces, the lecture was open for questioning and redirection. Occasionally, the graphic organizer contained a section that we completed together, and then a section that they completed in pairs or groups. After allowing the students 5 minutes to predict the answer based on concepts that had been presented, I then demonstrated the correct completion of the graphic organizer. As previously described, each lecture culminated with cooperative groups structured around the solution to the case study problem at hand.

"Thinking Activities"

Thinking activities in the course were composed of both hands-on and minds-on experiences. In each class period, an introductory activity engaged the student in a review of concepts from previous classes, reinforced their knowledge by application, or introduced ethical and open ended issues about pharmacology. These activities ranged from 5 to 30 minutes, depending on the topic. The remainder of the class period was
constructed as the previously described 10-2 structure and then case study group time. Oftentimes, the case study groups remained discussing concepts well after I packed up my computer and left the room. Class periods were 2 hours long, twice a week for 7 weeks (summer session).

As one of the knowledge by application activities, we utilized a 3D molecular modeling software program on wireless laptops. There are many molecular modeling software programs available on the internet (Millar, 1996). After the in-class tutorial, the students could download the software for free to their home computers. As shown by many researchers (Morvillo, Schmidt and Carlson, 2000; LoPresti and Garafalo, 1991) molecular modeling activities help students understand the three dimensional aspect of molecules. In this course, the modeling program was used to visualize how drugs bind to receptors and how enzymes work to metabolize drugs. The concept of receptor and drug interaction had been introduced in the previous class period. Figure 4 is an example of the SwissPDB Viewer software visualizing the monamine oxidase enzyme and its active site. Students identified the active site by highlighting the beta pleated sheets and the alpha helices of the receptor protein, by identifying the polar amino acids, and then by manipulating the drug molecule to fit into the active site of the protein.
Other thinking activities asked students to review the mechanisms of drug action in the neural synapse ("7 ways to leave your neuron") and evaluate over the counter herbal drugs and their medicinal claims ("Can they do that?") for example. Each thinking activity presented an opportunity for me to informally assess the students. In some cases, the activity was turned in, so that I could keep a written record of their development.

How was the class extended by the online environment?

There was a strong online component of the course and this perspective added benefits as previously documented by other researchers (Chamberlain, 1998; Francis, 2000; Seitz & Leake, 1999). Since the course also had a face-to-face component, the problems of communication seen with distance learning courses were not present (Palmquist, 1999). Students signed on to the web component of the course during the first class period using portable wireless networked laptops. I walked them through each operation needed to work and communicate within the course. For some, written tutorials were too confusing, and the actual signing on in a supported environment was most beneficial.

Beginning on the first day, students knew that the course had an online component that was not voluntary; it was required and integral. The online portion of the course was the main communication tool for the course when not in class. The course utilized WebCT for the course tools of email, chat, bulletin boards and quizzes. All of the case studies were on the website as well as the links to all databases, the descriptions of the projects, and the extra credit opportunities. All projects were submitted online using an assignment dropbox. Students came to scheduled chats with questions before the tests and I assisted them in either finding the answer or conducting a review lecture online in the chat. These chat rooms were well visited and I posted the transcripts for those that may have not attended. Chats were also used to help students find online resources for their projects. In addition, I communicated by email with students about their concerns in the course. The online environment allowed timely feedback that is critical to student understanding and investment in the course. I concur with Collins (1996) that there are positive uses for online bulletin boards and chats (Kimbrough & Hochgurtel, 1998).

Nelson (1998) describes many online evaluation tools such as tests with multiple choice, discussion questions, essays and authentic projects. I designed various methods of assessment that involved the online environment. One method, the PharmChallenge quizzes, were two question multiple choice online quizzes about extra articles students could read and from which students could obtain extra credit points. The topics of the two page articles were an extension of the concepts covered in class, and many times expanded the terminology or knowledge base for the student interested in that topic. An example being an article on the neurotransmitter serotonin, while the neurotransmitter dopamine is the one focused more on in class. A second example is an article on acne medications, since other “teen” medications were discussed in class.

One evaluation tool in particular not only allowed me to assess students but also supported an online learning community. A PharmQuest is a question or an answer to someone else's question on the course online bulletin board about a drug in society. This was the part of the course that occurred outside the classroom and extended the concepts discussed in class. The PharmQuest postings centered around student driven questions about drugs and thus were applicable to everyday life. This was a very active component of the course, as there are over 300 postings from 33 students.

Range of Assessments

Glasgow (1996) categorizes assessment strategies into three areas of content, process, and outcome. Content is concerned with the knowledge students acquire, in this case pharmacological knowledge. Process assessment focuses on the student’s ability to apply knowledge in solving problems. Outcome assessments involve the products students design that shows their combination of content and new applications of knowledge. More commonly, this translates to what the learners know, how they think and what they can do. In content areas such as Pharmacology, and the understanding of drugs in our society, an additional assessment would include not only what students know and what they can do with what they know (skills), but also, how do they feel about societal issues interlaced in the study of drugs? This question prodded me to include alternative types of assessments in order to uncover student’s attitudes or affects.

Many assessments fall under the umbrella of Performance Based Assessments. These are usually defined as assessments that are not the traditional multiple choice test that assesses recall of factual content knowledge. Examples include alternative assessments, portfolios, essays, journals, etc. Many of these assessments may be
authentic in nature. Wiggins (1990) stresses that assessment is authentic if it is realistic and requires that students use knowledge obtained in many ways. He states:

“Assessment is authentic when we directly examine student performance on worthy intellectual tasks. Traditional assessment, by contract, relies on indirect or proxy ‘items’-efficient, simplistic substitutes from which we think valid inferences can be made about the student’s performance at those valued challenges.”

Herrington and Herrington (1998) have defined seven characteristics of authentic assessments and describe how they were operationalized in a technology rich learning environment. Alternatively, Terwillinger (1997) concludes that the promotion of authentic assessment is flawed because the term ‘authentic’ is misleading. He further states that it is wrong to deny the role of knowledge in the assessment of performance. But enough evidence is beginning to emerge that shows authentic assessments to include the role of content knowledge, and the term ‘authentic’ is taking on the meaning of “the student’s own constructed responses and other creations (ERIC descriptor)”. This does not eliminate content knowledge, nor does it preclude the use of authentic assessments combined with traditional assessments to offer a range of assessments.

I chose to offer a range of assessments to evaluate content, process and outcome, as well as attitude. Included in the assessment plan were two forms of authentic assessment: The Pharmaceutical Concoction Project and the PharmQuests mentioned previously. The Pharmaceutical Concoction project (see Figure 5) was designed to have students look at medicine in our society, and had a historical as well as practical application. Since the majority of the students in this course were teachers, the societal impact of medicinals was an important perspective to investigate. Many pharmaceutical concoctions were compounded and advertised during the early 1900s. Amazingly, many of these preparations are still in use today, either sold over the counter, compounded by the elderly in a family, or acquired from other countries. These concoctions may or may not be proven to work. This project was a fact-finding investigation into what we know about the history of use of a pharmaceutical concoction, the presumed effectiveness, the probable method of action and the societal effects of the pharmaceutical preparation. Some of these drugs were combination products, while others were natural products used in tinctures or teas. Many of these appeared on pharmacy shelves during the first half of the 1900s, while others were important medicinals of earlier eras, or are in current use.

I introduced a multimedia Flash presentation describing the use of medicinals in our society, and the project description. Students were asked to randomly choose a medicine vial with the name of a Pharmaceutical Concoction inside. These projects required the students to integrate what they had learned about pharmacology in the course, investigate historical and societal aspects, and conduct research on the internet about the chemicals in their concoction and the diseases the concoction is intended to treat. Students were also encouraged to interview pharmacists about their concoctions. The students presented a multimedia powerpoint presentation.
about their concoction at the end of the course. Students were aware of the specific criteria for the project and the associated rubric.

Three in-class tests combined multiple choice questions for basic factual knowledge, essays for critical thinking, and “Fuzzy Situations” (Hanna, 2000) for knowledge application and future knowledge prediction. Also in class, there were many thinking activities in which students participated that produced case study solution sheets, molecular modeling screen prints, graphic organizers and other pair or group projects. Bostock (1998) describes a constructivist course design in which the learners have personal control, there are authentic learning contexts and diverse personal interactions including collaboration define the learning environment. He concludes that authentic assessment was critical, and web communication forms supported some necessary personal interactions, but collaborative work was problematic since the course was online. The advantage of the multi-modal course approach is that it circumvents to exclusionary problems with solely online collaboration since the face to face collaboration still exists, while allowing new methods of collaboration to develop in the online environment.

**Linking Objectives to Assessments**

I designed this course to enable non-pharmacy students the opportunity to appreciate the complexities of drug dosing and mechanisms of action in order for them to be able to approach drug issues in their own lives or jobs with an informed knowledge base. The objectives printed on the syllabus include:
1. Discuss pharmacological terms and concepts.
2. Identify opportunities to incorporate pharmacology issues/applications into science curriculum.
3. Use the internet to locate and utilize resources for enhancement of pharmacology knowledge and understanding.
4. Gain perspectives on the way drugs are dosed and understand drug dosing curves.
5. Have a working knowledge of how drugs act and be able to identify the general drug action for newly marketed drugs.

<table>
<thead>
<tr>
<th>Objective- Learning Outcome</th>
<th>Activity/strategy</th>
<th>Mode</th>
<th>Evaluation Component</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss Pharm. terms and concepts</td>
<td>case study lecture graphic org initiating activities</td>
<td>in class</td>
<td>content outcome</td>
<td>test-MC Concoction PharmQuest case study form GO completion Initiating activity</td>
</tr>
<tr>
<td>Incorporate pharm issues/applications into curriculum</td>
<td>email chat initiating activities</td>
<td>online in class</td>
<td>process</td>
<td>test-essay PharmQuest</td>
</tr>
<tr>
<td>Use internet for resources and concept enhancement</td>
<td>PharmQuest Mol modeling email chat</td>
<td>online</td>
<td>process outcome content</td>
<td>3D screen print email PharmQuest Chat Concoction</td>
</tr>
<tr>
<td>drug dosing and dose curves</td>
<td>case study lecture graphic org</td>
<td>in class</td>
<td>content process</td>
<td>test-MC PharmQuest Concoction case study form</td>
</tr>
<tr>
<td>working knowledge of drug actions--&gt; new drugs</td>
<td>PharmChallenge initiating activities</td>
<td>online in class</td>
<td>outcome</td>
<td>test-essay Concoction PharmChallenge</td>
</tr>
<tr>
<td>evaluate trends in research</td>
<td>PharmChallenge fuzzy situations</td>
<td>online in class</td>
<td>outcome</td>
<td>PharmChallenge fuzzy situations</td>
</tr>
<tr>
<td>students-drugs and effects</td>
<td>case study lecture PharmQuest</td>
<td>in class online</td>
<td>process content</td>
<td>test-MC Concoction case study form PharmQuest</td>
</tr>
</tbody>
</table>

*Table 1: Chart identifying links from objectives to assessments*
6. Critically evaluate new pharmacological trends in research and assert how the knowledge may be used in the contemporary science classroom.
7. Become aware of the drugs students are using and obtain pharmacological information on the effects of these drugs.

Borrowing from models by Hsu (1999) and Glasgow (1996), I developed assessments that required complementary instructional strategies or activities in either online or in-class modes in order to evaluate content, process or outcomes. Each of these activities and assessments must match the objectives of the course for the learning to be meaningful and the outcomes realized (see Table 1).

Discussion of the Effectiveness of the Evaluations

A multi-modal learning environment created a positive learning experience for science teachers in this introductory course on Pharmacology. Through various forms of planned assessments, I was able to evaluate student’s knowledge of basic pharmacological concepts, observe their skills in working with pharmacological terms and concepts in problem-based case studies, and perceive their attitudes about drug issues in their schools and in society. My goal was to more richly inform my understanding of what the students knew by incorporating authentic assessments that would enable them to expand on knowledge “transmitted” or constructed in class. The online component to the course supplied an added benefit that was not predicted.

<table>
<thead>
<tr>
<th>PharmQuest Criteria</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>use of terms</td>
<td>Q/A incorporates original use of terms and explains concepts in authentic words</td>
<td>Q/A incorporates some original language, but some is cut and pasted from sources</td>
<td>Q/A cuts and pastes from other sources, no evidence that student understands</td>
</tr>
<tr>
<td>examples from class</td>
<td>examples from class are incorporated in Q/A in meaningful learning</td>
<td>examples from class are hinted, and some explanations included</td>
<td>examples from class may be mentioned, but no explanation</td>
</tr>
<tr>
<td>integration of ideas</td>
<td>Q/A integrates more than one concept</td>
<td>Q/A should integrate concepts, but does not</td>
<td>simple one concept question or answer</td>
</tr>
<tr>
<td>application based</td>
<td>Q/A applies knowledge to new information with good explanation</td>
<td>Q/A refers to applying knowledge, but does not explain</td>
<td>recall of factual information not application based</td>
</tr>
</tbody>
</table>

Table 2: Rubric for the evaluation of PharmQuests

The PharmQuests on the Bulletin board were most informative of the students’ construction of knowledge in pharmacology. When I conceived the idea of PharmQuests, I thought the students would just banter around ideas of drugs in TV commercials or the internet. What occurred was beyond my expectations. I was able to formatively assess the student's progress in the use of pharmacological terms by reading their PharmQuests online. At the beginning of the semester, the PharmQuest postings were general and shallow. Most postings just asked about the mechanism of a drug and someone would answer with an easily recognizable cut and paste description from a pharmacy database. When asked to explain, the students could not put the explanation in their own words, or translate the highly technical pharmaceutical language. As the students learned more in class, the postings began to be more application based, with correct and appropriate use of information about the drug. It became apparent that the students did not just cut and paste information. They were really discussing the
drugs and mechanisms with terminology and examples I had used in class. As evidenced by the rubric I
developed to rate the content of each posting (Table 2), the PharmQuest postings became more content rich and
application oriented as the students began to understand pharmacological terms and mechanisms.

The data from PharmQuests show a transition from cut and paste answers of simple one concept factual recall
questions to integrated and application-based questions and answers with appropriate use of pharmacological
terms (Figure 6). The transition occurred over the 7 weeks of the course. The students posted almost every day,
including weekends and late evenings. Commonly, one question would initiate a cascade of answers, comments
and then questions again. The power of the bulletin board discussions lies in the ability of the data to be collected
from individual students as well as the class as a whole. Each week, I tabulated the postings from the bulletin
board according to the PharmQuest criteria in Table 2 above. The total rubric score from all students on each
criteria was plotted below for each week. The graph shows a significant increase in the rubric scores for the ‘use
of terms’ and the grounding of their postings to be ‘application based.’ The ‘integration of ideas’ also increased,
although not as drastically. I would expect students to integrate concepts more as the course developed, but since
their knowledge of pharmacology is not broad, it was encouraging to see a positive movement toward integrated
concepts. The students used ‘examples from class’ in a consistent manner throughout the course.

![PharmQuest Class Total Score from Rubric](image)

Figure 6: Class data on PharmQuest postings

The products produced by the students in the Pharmaceutical Concoction project evidenced their conceptual
understanding as well as their attitudinal outcomes. Many students delved deeply into areas we had not discussed
in class in order to describe their concoction. All students came to a conclusion about the effectiveness of their
product, or lack thereof. Many students focused their presentation on the influence the concoction had on
society, and some their own family. This past year, an older pharmacist communicated through the course
website with many of the students, assisting them in their projects. In most cases, the material for this project
could not only be found online, so students had to be very resourceful. The students felt confident that by posting
their projects online, they had added to the factual knowledge available on the internet about their concoction. In
class, students taught their peers about their Pharmaceutical Concoction through the use of technology, hands-on
activities and visual aides (see Figure 7).

Analyzing the data from PharmQuests, the examinations, the optional PharmChallenges and the transcripts from
chats and e-mails, main themes of evaluation through online-assisted courses emerged. As a main theme, the
online component, if used formatively, may inform the instructor of the “knowledge to application” conversion
before a pen and paper summative examination. Students felt more open to express their misunderstanding of
concepts through non face-to-face means. Online collaboration between students extended the scope of the
concepts covered in the course and the instructor was able to link online discussions to subsequent lectures and
activities.
Conclusions and Implications for Technology Infusion

In suggesting which evaluations made the best use of technology, I would like to point out the assessments that were totally online and subsequently could not have been as effective in class. The use of online bulletin boards has been promoted by course developer companies such as WebCT. In their course preparation materials, most mention collaboration and communication as benefits of using online forums. In this course, an additional benefit was the evidence of the knowledge to application conversion. Since students were posing authentic questions and answering questions with their best “knowledge” to date, a continuum of responses clearly demonstrated a student’s development from “informed but not knowledgeable” to “knowledgeable and able to apply”. This development could not have been observed so distinctly in class. The fact that students could cut and paste definitions and mechanisms of action from internet sources at any time, but developed into answering questions with self-learned and class-enriched knowledge and terminology, demonstrates that workable knowledge replaced “borrowed” knowledge.

The PharmChallenges were also completely online, and 80% of the students earned full extra credit points. Students liked the opportunity to investigate other topics not directly mentioned in class, and take the quizzes online on their own time. The multiple choice questions were not recall based questions, but required the student to read the information and then apply that information to a new drug or situation. Prior to taking the first quiz, many students commented on the open book nature of the quiz, but after reading the quiz questions, realized that the application of that new found knowledge was the only way to insure success. This was an excellent use of technology to evaluate knowledge application that did not take up time in class.

Other uses of technology in the course were important for knowledge construction. Modeling receptor active sites and positioning drugs for action through a computer based 3D program enabled students to view molecules in ways that words and 2 dimensional drawings did not convey. The integration of many computer animations into the lecture periods also aided in conceptualization of dynamic systems. The graphic organizers were used in class, but students were able to download and print the organizers prior to class. The course website provided links to databases and appropriate drug websites to aid in student’s research. E-mail communication added the personal, but private, avenue for students to express concern in their progress in the course. Although the Pharmaceutical Concoction project may have been accomplished without software for presentations, the visual record of the presentation remains on the website as evidence of their work.

Integrating new strategies of instruction while evaluating new assessment tasks is an ominous endeavor for instructors. By organizing online and in-class experiences to augment knowledge construction in a content,
process and outcome schema, the evaluation task became seamless with the instructional mode. In this science concept rich course, the online environment provided an extension of the class concepts and evidence of student learning. In particular, the progression from “informed but not knowledgeable” to “knowledgeable and able to apply” was readily evident in online communications. Further studies should investigate the application of the PharmQuest rubric to other content, and the integrated assessment plan must be compared to more traditional courses in a systematic manner.

References


Additional Materials

Student Responses to the Course
1. Very effective and enthusiastic teaching. I also liked the grading table on the website so we knew exactly how many points each thing was worth and what we scored.
2. Intense content! Was very challenging- loved the intellectual stimulation. Dr. Hanna selected excellent topics and presented them well.
3. Interesting information. Supplemental material offered strove to keep students’ attention. Graphic organizers were great! Always available and willing to help. Definitely above and beyond. Liked PharmChallenge and PharmQuests.
4. Versatile, knowledgeable, very creative in presenting information. Organized and effective teaching style.
5. It was refreshing to have a professor who did not stand and lecture for 3 hours and then give an exam. We actually did activities in class.
6. What a wonderful experience! Great class! I loved your use of technology.
7. Very helpful- personally important content.
8. Provided opportunities to increase student knowledge and allowed students to converse and share information using a classroom bulletin board.
9. Very interesting class that I learned a lot in
10. This was a great class. I am so glad I was able to take it. Thanks for all of your time and effort. I know we all learned a lot.

Course Website

I have placed the homepage of the course and some additional pages outside of WebCT to allow guest access to most of the course ideas. The homepage is at: http://www.gsu.edu/~mstnrhx/pharm/pharmcov.htm

The Guinea Case

Cavy is a stocky guinea pig with short legs. She has long straight hair in brown and cream that grows very rapidly and distinguishes her as a Peruvian guinea pig. Even with the long bush of hair, it is evident that Cavy is overweight. Cavy has been the laboratory guinea pig for seven years. She has been involved in the development of various drugs and dosage forms. Obviously, her involvement has been as the front line patient for drugs being tested. Cavy has had the opportunity to experiment with 16 drugs over the past two years. Cavy was perfect for the job since the lab tested psychoactive drugs and Cavy's brain is very similar to a human brain. Cavy has had her share of nicotine, cocaine, opioids, hallucinogens and of course alcohol.

Cavy has been treated well as far as living arrangements and amenities. She has had all the vegetables and fruits necessary to support a healthy guinea pig. The favorite part of her diet is the cacao nuts that the science department has flown in from Peru especially for Cavy. She eats cacao beans and pineapple juice three times out of the 6 meals she usually has every day.

A sociable gal, Cavy has had two partners in the past 2 years. She has not, however, had any offspring. Recently, though, Cavy has withdrawn from socialization and seems to be spending more time eating.

Yesterday, a graduate student noticed that Cavy was making strange movements—almost seizure like actions. The graduate student took Cavy to the pharmacologist to ask what to do about the seizures. Evidently, after two years of drug trials, Cavy has developed a form of epilepsy.

Since Cavy is so near and dear to the science department, they took blood samples in order to decide what type of therapy would be appropriate for Cavy. (The results of the blood test and profile for Cavy are available for your review.)

The pharmacologist decided that they would try to control the seizures with phenytoin.

What would you need to know to dose Cavy?
What are some specific considerations in dosing Cavy?
What would be the appropriate dosing regimen of phenytoin for Cavy?
The Case of Albert

Alcoholism and Drugs of Abuse - primary drugs of the young generation. Enzymes, interactions, neuroregulation, inhibition, stimulation, replacement and depletion.

Albert was a good looking boy of 16. He didn't play sports, but seemed to have quite an aptitude for music. He had friends of all types, from every "clique" in the school. But Albert was one of those kids in school that always seemed to blurt out unusual sentences in the middle of class. Some days, his responses made sense in the context of the class, but most times they were off the wall. He would laugh at nothing, just start laughing to himself. Most of the other students knew that he smoked pot and drank alcohol. But lately, Albert seemed to be coming up with more outrageous remarks, and then not really remembering that he said them. Students were commenting on how he had changed.

While he used to be able to sit in class for the whole period, now he gets up and walks around - agitated and anxious. Albert liked to eat candy in class, but now said he had no desire to eat sugar anymore. One day while doing cooperative groups in class, the noise level was a little bit louder than normal, but to Albert, the noise was deafening. He said that he had to leave the room. Another day in physics class, students were designing and building a rollercoaster. Albert was able to participate and contribute to his group. At one point, one of the machines fell off the counter and landed on Albert's toe. He did not flinch. He felt no pain.

His sister said that she saw Albert rummaging through his mother's medicine cabinet in February. His Mom had some difficulty coping with things and sometimes had anxiety attacks, and so the doctor had placed her on some medications. His sister also noticed that the supply of medicine seemed to be diminishing.

Last Friday night, Albert was admitted to the ER with elevated blood pressure, a rapid pulse, bronchodilation, paranoia, pupillary dilation, chest pain and a body temperature of 101 degrees. Albert thought he was having a heart attack.

What had really happened to Albert?

The Case of Melanie

Anorexia - the use of diuretics, anxiolytics and antidepressants. Acid/base chemistry of elimination, alternative medicines, adverse reactions, the nutritional balance

Melanie was a very popular 11th grade cheerleader who loved athletics. She attended aerobic classes five times a week. She had many friends and a cute boyfriend named Scott who loved for her to wear tight clothing. She was a slim 102 pounds on a 5'7" frame.

Scott loved Melanie and thought they had a wonderful relationship, except there was one thing Melanie would not do with Scott...go out to a restaurant and eat dinner. Melanie was very conscious of her diet and carried a calorie counter book in her purse. Melanie was very "in tune" to her body, and if there was just a slight puffiness at her waist or stomach, Melanie would drink herbal tea to release the extra water weight. Melanie said she was always going to the bathroom because of the diuretic effect of the herbal tea.

A new coach came to the high school and wanted all of the girls to try out for cheerleading again. The coach came from a top cheering squad and seemed to have a different vision for the team. Melanie did not make the cheerleading team. This put Melanie in a depressive mood. Melanie's mom became worried about her depression and took Melanie to the doctor for antidepressant medication. The pills worked for a period of time and Melanie began to go to social events and even eat at restaurants. But after 6 months, Melanie began to lose weight.

One evening, Melanie fainted in aerobics class. She was admitted to the hospital with shallow breathing, hypotension, dehydration, and cardiac arrhythmia. Her blood tests showed low potassium levels, low protein and albumin, and low magnesium. She weighed 71 pounds.

What has really happened to Melanie?