The Use of Student-Centered, Problem-Based, Clinical Case Discussions to Enhance Learning in Pharmacology and Medicinal Chemistry

Richard N. Herrier, Terrence R. Jackson and Paul F. Consroe
College of Pharmacy, The University of Arizona, 1703 East Mabel, Tucson AZ 85021-0207

INTRODUCTION
Traditionally, pharmacy education has consisted primarily of didactic, subject oriented and knowledge-based teaching. While these are essential methods, they do not provide optimal opportunities to learn processes needed to identify and treat drug related problems confronting today’s practicing pharmacist(1). In 1975, the Millis Study Commission on Pharmacy listed problem identification, problem solving, and continuing education as essential skills needed to practice in any health service profession(2). Unfortunately, concerns have been voiced in the pharmacy literature that students are entering clerkships without appropriate problem solving or clinical decision making skills(3,4). Similarly, a significant need to improve problem solving skills has also been documented among community pharmacists(5).

To improve problem solving skills and link basic sciences to clinical practice, medical educators have turned to problem based learning (PBL) as a partial replacement for traditional didactic approaches to teach basic and clinical sciences. Instead of traditional lecture based format, students learn by solving problems. Instead of sitting in class taking lecture notes, students take active responsibility for their learning in the student centered, problem based format(6-9).

Student centered, problem based learning methodology utilizes collaborative study of clinical cases in small discussion groups, facilitated by faculty direction that concentrates on group process(10). Problem based, student centered learning develops clinical reasoning strategies through scientific understanding of basic sciences. In addition, problem based learning facilitates the assimilation of new information by allowing knowledge to be learned in the context in which it is to be applied(1,5-10). Problem based case discussions force students to use hypothesis driven reasoning, which is more effective than lectures in developing problem solving ability because students must apply scientific knowledge to problems in clinical cases(3,6-8).

This method of instruction has been shown to create a knowledge base that is recalled as well as, or better than,
information learned by standard memorization learning methods(9,10). Comparisons with medical students and graduates receiving traditional teaching methods have demonstrated the superiority of problem based learning for diagnostic ability, self learning skills and in student course evaluations(9,11-13). Given the needs of the pharmacist to identify and solve therapeutic problems in delivering pharmaceutical care, the student centered, problem-learning is an appropriate tool to meet the many competencies required for the entry level doctor of pharmacy(1,5,10).

Experience with student centered problem based learning in the basic pharmaceutical sciences has been limited. Several articles have evaluated the utility of student centered problem based approaches to teaching basic sciences(14-16). Lush(14) and Duncan-Hewitt(15) described the structure, content, success, and evaluation methods of PBL courses in clinical research design and pharmaceutics. Winslade evaluated PBL in a pharmaceutical therapeutics class, using Likert scale statements in two survey instruments. One evaluated student attitudes and the other assessed faculty perceptions(16).

In 1995, the College of Pharmacy began implementation of a major curricular change. Goals of these changes included introduction of patient and drug related material earlier into the curriculum and increased use of case discussions on clinical topics in every semester of the three years the students are on campus. Student centered, problem based case discussion courses were added to each of the first three semesters. The case discussion courses during the first year focus on the application of materials learned in immunology, patient assessment, biochemistry and physiology. Cases discussions during the last three semesters are part of the pharmacotherapeutics course. The third course in the series, case discussions in pharmacology and medicinal chemistry (PhPr 422) was designed to have students to apply material concurrently learned in pharmacology and medicinal chemistry. A student centered, problem based format was selected for this case discussion course because it appeared to provide the most effective method to meet the desired outcomes for the course (Appendix A).

**COURSE DESCRIPTION**

Students were concurrently enrolled in two separate didactic courses in pharmacology and medicinal chemistry, which closely coordinated lectures of the same topics. The case discussions were held weekly and case topics were coordinated so that students applied the didactic material covered in pharmacology and medicinal chemistry lectures during the previous five to ten days (Appendix B). After three introductory lectures regarding clinical problem identification and problem solving, student-centered/problem-based processes and course logistics, the class of fifty-four second professional year students was broken down into six discussion groups of nine students. To each of the two hour case discussion session students brought pharmacology, medicinal chemistry, and therapeutics textbooks, plus course notes in pharmacology, medicinal chemistry and patient assessment. USP-DI. Facts and Comparisons, APhA Drug Information Handbook, and a clinical laboratory reference text were optional resources. At the beginning of the discussion session, the faculty facilitator handed the students a case scenario containing patient data. The students then proceeded to identify and evaluate potential problems, eventually leading to the development of appropriate solu

tions. In addition, students were required to complete a series of short questions which reinforced the application of basic sciences to the case scenarios, covered key relationships between the patient’s problems and knowledge of pharmacology and medicinal chemistry, or supported student comprehension of essential material. The group next developed brief schemata for one or more of the drug classes covered in the case. These schemata served to assist in the quick recognition of potential problems involving this drugs. For each case, several students were required to document the group’s activities. One student reported the group’s findings using the SOAP format, another summarized the group’s brief answers to the questions. Others reported problem identification schemata, identified learning issues, and the group’s evaluation of the case (Appendix C). All of the above were due at the beginning of class at the following case discussion session.

One facilitator, a member of the clinical faculty, was assigned to each discussion session. Facilitators rotated among the six groups. The facilitator did not teach or lecture. When the group progress stagnated or discussion became non-productive, the facilitator used open-ended questions to guide the group in a more appropriate direction. Because of the considerable experience of the faculty in facilitating PBL case discussions in pharmacotherapeutics, no formal training was provided. However, written material regarding the role of the facilitator in student centered, problem based case discussions, adapted from that used by the Colleges of Medicine at the Universities of New Mexico and Arizona, was provided to the facilitators. The facilitator was provided a guide for each case that contained the case scenario, detailed answers to questions, process problems likely to be encountered, and suggested solutions to process problems (Appendix D).

**METHODS**

Three major tools were used to evaluate the study objectives; a test evaluating knowledge and problem identification skills administered at the beginning and end of the semester, a student evaluation, that included an attitude survey done at the completion of the course (Table I) and changes in examination scores and grade distribution in pharmacology and medicinal chemistry. The pretest and posttest for knowledge and problem identification skills was developed from materials covered in these courses and consisted of three short simulated case studies differing in levels of difficulty. Students were allowed six minutes to identify multiple drug problems in each case. The attitude survey consisted of nineteen statements using a Likert scale to determine levels of student agreement with each state
ment, where one equals strongly disagree and five equals strongly agree. Pharmacology examinations, which used a similar limited pool of questions each year, were used to compare scores of the class of 1999 with two previous classes of first semester pharmacology. This approach was chosen for evaluation because the class procedure of not returning examinations had resulted in a high level of consistency in average class scores over the last ten years. Differences between scores in 1994 and 1995 were not significant (P=0.454), which was consistent with scores prior to 1994. In addition to the three main tools, each case was evaluated by students and the facilitator in each group. These evaluations consisted of open-ended questions that served to identify strengths and weaknesses of each case and allow for intracourse modification of cases and processes.

RESULTS

Pre- and Posttest for Problem Identification Skills and Knowledge

A test containing three brief scenarios was administered in which students were asked to identify potential problems. The test, given both before and after the course, evaluated knowledge, problem identification skill, and problem solving ability. Post test scores showed significant improvement over pretest scores (P=0.001) using a paired t-test. Out of a possible 41 points, students increased scores from an average of 2.84 ± 3.58 to 9.14 ± 6.57 (a difference of 6.3 ± 5.74). Three of 49 students demonstrated lower scores on the post test than on the pretest, fourteen of 49 students demonstrated an increase in score of ten or more points.

Scores on Pharmacology Examinations

The increases in scores in fall 1996 when compared to Fall of 1994 and fall 1995 classes, represent a major improvement in student performance. There was an absolute increase of four and one-half percent between 1994 and 1996 scores (P=0.001). Differences between 1995 and 1996 were similarly significant (three and one-half percent; P=0.004). The number of A’s and B’s increased from 50 and 56 percent in 1994 and 1995 to 84 percent in 1996 (Table II).

Scores on Medicinal Chemistry Examinations

No comparisons could be made on medicinal chemistry scores due to unexpected changes in testing procedures and in course material.

Student Attitude Survey

The results of the survey are listed in Table I. Forty of the 54 students completed the attitude survey. Results were categorized with scores of four and five indicating agreement and one or two indicating disagreement. Pearson Product-moment correlations were calculated to determine relationships in responses among statements. Regarding self-learning skills, 75 percent of the students expressed confidence in their self-learning skills and two thirds felt the case studies had improved their abilities in that area. There were moderate positive correlations between those questions related to self learning (r= 0.578-0.686). Regarding problem identification skills, 75 percent felt that the cases had helped improve their problem identification skills, which correlated strongly with two-thirds of the students who felt that the case studies helped improve their clinical reasoning skills (r= 0.700). Regarding improvement in knowledge,

Table II. Student attitude survey results (n= 40)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The cases helped me develop skills in identifying potential drug related difficulties of the patient.</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>2. The cases stimulated my desire to learn.</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>3. The cases improved my ability to apply concepts of basic sciences to clinical situations.</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>4. I feel confident about my self-learning skills.</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>5. I feel confident about my problem identification skills.</td>
<td>0</td>
<td>2</td>
<td>10</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>6. The case studies helped me to evaluate skill levels and areas that needed improvement.</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>7. I feel comfortable advising a physician on the subject matter covered in the cases.</td>
<td>3</td>
<td>11</td>
<td>13</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>8. The case studies were a good way to practice the integration of skills and knowledge learned in various classes.</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>9. I feel confident about my clinical reasoning skills.</td>
<td>0</td>
<td>5</td>
<td>13</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>10. The case studies reinforced information taught in other classes.</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>11. The case studies enhanced my clinical reasoning abilities.</td>
<td>0</td>
<td>4</td>
<td>9</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>12. The emphasis on clinical concepts was a detriment to my learning of basic sciences.</td>
<td>4</td>
<td>15</td>
<td>9</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>13. My learning of facts, diagnostic and therapeutic skills were significantly enhanced by these case studies</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>14. I feel confident in applying basic science knowledge to the solution of clinical problems.</td>
<td>0</td>
<td>4</td>
<td>11</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>15. The case studies helped me in learning pharmacology.</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>16. The case studies helped me in learning medicinal chemistry.</td>
<td>7</td>
<td>8</td>
<td>18</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>17. I prefer a different method of learning.</td>
<td>1</td>
<td>21</td>
<td>10</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>18. I learn more with other teaching methods.</td>
<td>1</td>
<td>14</td>
<td>17</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>19. The case studies improved my skills in teaching myself new materials.</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>23</td>
<td>3</td>
</tr>
</tbody>
</table>
more than sixty percent felt that the case studies had helped them learn pharmacology, and a similar percentage of the students felt the cases had improved their ability to apply basic science concepts to clinical situations. Unfortunately, only fifteen percent felt the course helped them learn medicinal chemistry. Eighty percent (32 of 40) felt the case studies were a good way to practice the integration of skills and also reinforced knowledge learned from other classes. Responses to these questions showed a strong positive correlation (r= 0.786). Those that felt confident about their clinical reasoning skills also felt confident about applying basic science knowledge to the solution of clinical problems and that the course aided in improvement of problem identification skills (r= 0.719-0.747). There were moderate to strong correlations among questions regarding confidence in problem identification, clinical reasoning, self-learning skills, and application of basic sciences to clinical situations (r=0.632-0.820). While the overall response to the course was positive, about twenty percent of the respondents preferred teaching methods that differed from the student-centered problem-based case studies and felt that the clinical aspects may have hindered learning of basic sciences.

DISCUSSION

The overall impact of the course was very positive. Results met most expectations and were consistent with those found in the medical, nursing, dental and veterinarian literature(11-13,17). The improvement in scores and grades in pharmacology were impressive. Since there was no control group, the class of 1999 could have just been better students compared to previous classes. However, comparisons of examination scores and grades from anatomy, biochemistry and physiology did not reveal any differences between classes. In addition, previous patient assessment and case discussions (two semesters) during the first year of the new curriculum could have positively impacted both knowledge and skills related to pharmacology and could have accounted for part of the improvement. Scores and grades for the second semester of pharmacology, subsequent to the case discussion course were also better than previous years, but did not reach statistical significance (P=0.12). While this subsequent improvement in test scores most likely represents carryover of the improved learning from the first semester, especially regarding autonomic pharmacology, it could also support the hypothesis that the skills of the class of 1999 or the new curriculum were significant factors in the improved performance. Based on the student attitude survey, student response to the course was also very positive regarding improving those skills needed to function in a patient care environment (problem identification, clinical reasoning, knowledge, self-learning, application of basic sciences).

The coordination of the cases with the lecture material in pharmacology was influential in the success of the case discussions course. The highest mean test scores on midterm examinations occurred when the case discussion, covering most of the material to be tested, was held several days prior to one of the midterms. Problems with the course also proved enlightening. While several sessions were devoted to processes and expectations, they were obviously not sufficient. It was assumed that the discussion groups would function similarly in effectiveness. However, there were difficulties with both group dynamics and group process. All groups took time to get adjusted to the new process. Four groups quickly adapted and became highly functional and effective. One was somewhat dysfunctional during the first several cases, but steadily improved to eventually match the other groups performance levels. However, one group remained dysfunctional throughout the semester in spite of attempts to correct the problems. All members of that group, which included some of the top students in the class, felt that they had not gotten the intended benefit from the case discussions. This may have been reflected in the student attitude survey where 20 percent of the respondents from the class felt that the course was detrimental to the learning of basic sciences and expressed a preference for other learning methods. To improve these aspects next year, students will be given more comprehensive lectures on effective group processes at the beginning of the course and another practice case will be added. Hopefully, this will allow for earlier identification of potential problems and make the groups more effective once they begin the actual cases.

One of the biggest disappointments of the course was its relative failure to improve students understanding of and appreciation for medicinal chemistry. A large part of the problem was the change in curriculum. The normal coordination between the two basic science courses was not maintained as well as in previous years, especially during the second half of the semester, due to a change in course coordinators in medicinal chemistry. In addition, the new course coordinator had a totally different emphasis on testing than the previous coordinator making comparisons of test scores impossible.

CONCLUSION

In summary, this student centered, problem based course, case discussions in pharmacology and medicinal chemistry met almost all the desired outcomes. Both student perceptions and more objective measures reflected student improvements in understanding of pharmacology, linking basic sciences to clinical applications, self learning skills, as well as problem identification and clinical reasoning skills. The students learned to deal with clinical problems in a “real life” situation, where may not have all the stored knowledge needed to identify and solve clinical problems. The results regarding the impact on medicinal chemistry were disappointing. In addition to performance changes, student confidence in their abilities regarding clinical problem solving skills markedly improved.

Am. J. Pharm. Educ., 61, 441-446(1997); received 9/15/97.

References
(7) Bligh, J., “Problem-based learning: an introduction,” ibid., 71, 323-
APPENDIX A. DESIRED COURSE OUTCOMES

1. To increase the students’ problem identification and clinical reasoning skills.
2. To link basic sciences to clinical applications.
3. To improve the ability of the student to self-learn.
4. To improve the students learning and retention of Pharmacology and Medicinal Chemistry material.

APPENDIX B. TOPICS COVERED IN CASE DISCUSSIONS

Case Discussion #1—Parasympathetic Nervous System
Case Discussion #2—Sympathomimetic Agents
Case Discussion #3—Beta Blockers
Case Discussion #4—Antianginals
Case Discussion #5—CHF
Case Discussion #5—Diuretics
Case Discussion #6—Antihypertensives
Case Discussion #7—Anticoagulants
Case Discussion #8—NSAIDS/Opioids/Pain relief
Case Discussion #9—Antihistamines/Asthma/COPD

APPENDIX C. EXAMPLES OF STUDENT REPORTS

LEARNING ISSUES

Case #1

A. Initial Potential Patient Problems Due to Drug/Disease
B. Things we had to look up
C. New Things learned from this case, NOT LEARNED in pharmacology/medicinal chemistry lectures about these drugs

CASE EVALUATION

Case #1

1. This case was:
   _Too easy_  _Easy_  _About Right_  _Difficult_

APPENDIX D. CASE SCENARIO: FACILITATOR’S GUIDE

CASE #1

PHPR 422

FACILITATOR’S GUIDE

TP #1 CONSTIPATION

S - Your regular customer, Howard Reeplesnap presents with a Fleet’s Enema for purchase. Upon further questioning he reveals a 3-4 week history of progressively worsening constipation. Normally bowel habits are 1 BM/day. Today is the 7th day without a BM. Howie denies any changes in diet, fluid intake, outdoor activity or exercise. In addition the patient feels that the constipation is worsening his heartburn problem. For the last two weeks his heartburn also worsened and has been complicated by bloating, abdominal fullness, belching and cramping LLQ, umbilical and suprapubic abdominal pain. Mylanta has not helped.

O - Patient has a 4 year history of GERD, well controlled for the last 18 months on bethanecol 25mg qid and metoclopramide 10mg qid. Patient has a 20 year hx of NIDDM well controlled on glyburide 2.5mg q AM (FBS range 100-140mg%). Patients neuropathic leg pain 2o to NIDDM has been greatly relieved since the amitriptyline dose was increased from 25mg q AM to 25mg bid on 8/19/97. Compliance on all chronic medications is excellent. Patient also suffers from seasonal allergic rhinitis for which he takes chlorpheniramine 12 mg SR q AM. Last prescription for 100 chlorpheniramine was filled on 7/12/96.

A - Constipation—unknown etiology
GERD—apparent loss of control 2o constipation

1. List the rationale for all probable causes for the patient’s complaints. Be specific, include any relevant pharmacologic mechanisms or structure activity relationships

A likely cause for Howie’s constipation is the increased antimuscarinic effects due to the increased dose of amitriptyline for pain of diabetic neuropathy. If he has also been taking his antihistamine, it would have additive antimuscarinic effects. However, given the onset of the symptoms in relationship to the increase in amitriptyline dosage, that increase is most likely responsible.
This increased antimuscarinic activity could also be responsible for negating the parasympathomimetic effect of bethanechol, which relieves GERD by increasing lower esophageal sphincter (LES) tone, thus reducing reflux.

The second probable cause of Howie’s problem in the progression of diabetic neuropathy to the gastrointestinal autonomic nerves aka diabetic gastroparesis. All his symptoms could be caused by this complication of the diabetes. While pharmacological agents such as cisapride and the motility agents already in use (bethanechol and metoclopramide) may have some temporary positive effect, Howie’s symptoms could be just due to a progression of the diabetic neuropathic disease and the drug change was just coincidental. As the neuropathy progresses all pharmacological agents lose their effectiveness.

NOTE: This is a major point of this case—Diseases can be the actual cause, even when it seems like the drug may be the culprit. Students tend to focus in on the drug and forget about the disease as a potential cause for patient symptoms

2. Why is the pharmacologic rationale of using bethanechol in the treatment of esophageal reflux disease (GERD)? What is the specific mechanism of action in this disorder?

Poor LES tone is thought to be a major cause of moderate to severe cases of chronic GERD. Bethanechol works via its parasympathomimetic effect, which increases lower esophageal sphincter (LES) tone, reducing reflux. NOTE STUDENTS MAY HAVE LEARNED THAT PARASYMPATHOMIMETIC EFFECTS RELAX ALL SPHINCTERS IN THE GI TRACT—in actuality it increases LES tone, while relaxing all others.

3. Why would you choose bethanechol instead of neostigmine, carbachol or methacholine in this patient? Identify structural and pharmacological factors for each agent

Neostigmine which acts by inhibiting acetylcholinesterase, allowing the accumulation of acetylcholine to produce parasympathomimetic effects. Unfortunately, it isn’t a good choice because if also has nicotinic effects which aren’t needed or wanted.

Bethanechol was developed by modifying the acetylcholine (ACH) molecule. ACH is very short acting due to its almost immediate destruction by acetylcholinesterase. It has nicotinic as well as muscarinic effects. These two parameters make it unsuitable for oral or injectable use. The addition of a beta methyl group to ACH reduces nicotinic activity by 1000 fold and makes it resistant to the effects of acetylcholinesterase. Carbachol, the carbamate ester of ACH has identical properties of ACH except that it lacks significant muscarinic effect on the heart and is more resistant to hydrolysis by acetylcholinesterase. Bethanechol is the carbamate version of methacholine which eliminates nicotinic activity, provides two different methods of resistance to acetylcholinesterase which makes it long acting compared to its parent compounds and therefore usable in an oral form. In addition the carbamate drastically reduces any muscarinic effects on the heart so that in normal doses, it primarily exerts muscarinic effects on the GI tract.

4. What alternative agents can be used in place of bethanechol? What are the similarities and differences in mechanisms of action of each of those agents?

Metoclopramide also increases LES tone and is useful in GERD. While it has cholinergic effects primarily on the lower GI tract, its mechanism of action on LES tone is less well understood. Both cholinergic and dopamine blocking actions have been proposed. While antimuscarinics would decrease its effects on the lower GI tract (causing constipation?), they would theoretically have much less effect on its LES actions.

Cisapride doesn’t have dopamine effects like metoclopramide, but exerts its effect via a cholinergic mechanism, possibly via a serotonin induced release of ACH. Antimuscarinics would block the effect of cisapride. In addition, cisapride is metabolized by cytochrome P-450 3A4 enzyme system and is subject to accumulation if given concurrently with 3A4 inhibitors such as ketoconazole, and erythromycin. Accumulation of cisapride results in Q wave prolongation and torsade de ponts like with aztemizole and terfenadine.

Agents that reduce acid production (H2 blockers—cimetidine or proton pump inhibitors—omeprazole) and/or neutralize gastric acid (antacids) are effective agents in the treatment of GERD and are used alone and in combination with agents that increase LES tone.

5. For each of the probable causes, explain your rationale for each recommendation or action. Be specific, include any relevant pharmacological mechanisms or structure activity relationships.

Diabetic gastroparesis-induced symptoms—not much can be done other than behavior changes (small feedings) and use of saline laxatives for constipation.. Could try changing neuropathy agent as below, which would allow prokinetic agent to be used for gastroparesis symptoms.

Antimuscarinic induced changes—The addition of an H2 blocker such as famotidine (not cimetidine due to P-450 inhibition) or omeprazole to decrease acid production might improve GERD symptoms. If that didn’t work it would require switching to another agent for neuropathic pain. Phenytoin, fluoxetine, and carbamazepine would be less effective alternatives that would have no antimuscarinic effect.