Problem-Based Learning: A Tutorial Model Incorporating Pharmaceutical Diagnosis

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This descriptive report illustrates the philosophy and curricular design of the Idaho State University College of Pharmacy problem-based learning (PBL) methodology. A four semester course sequence was initiated in the spring of 1993. The model, originally developed for use in medical education, features use of an ill-structured problem format and parallels a well established critical thinking process. The curricular objectives are to: (i) emphasize fundamental basic science concepts; (ii) develop a systematic process for identifying drug-related problems, termed pharmaceutical diagnosis; (iii) facilitate development of clinical problem-solving skills prior to clerkship entry; (iv) foster development of team-oriented interactive communication skills; and (v) inculcate a process for life-long learning. An abbreviated case example is presented to summarize the PBL stages and clinical problem-solving process.

INTRODUCTION
Development of teaching methods to enhance critical thinking skills is a well-recognized objective for improving pharmaceutical education(1-3). Consistent with this goal, Idaho State University College of Pharmacy implemented a problem-based learning (PBL) course sequence in the spring of 1993. While it continues to develop at a rapid pace, the philosophical approach evolved from an early recognition and desire to understand and develop the critical thinking skills necessary for pharmacists to identify drug-related problems (DRPs). A conceptual framework for this process, which we have termed pharmaceutical diagnosis is defined as a cognitive, problem-centered process used to identify patient-specific DRPs. Essential to this process is the need for comprehensive patient information gleaned from a variety of sources including: (i) patient and/or family interview; (ii) clinical findings observed during physical examination or documented in medical records; (iii) medical history of the patient or family; and (iv) pertinent laboratory and diagnostic information. Appropriate pharmaceutical diagnosis provides the foundation for the rational selection, implementation, and monitoring of pharmaceutical interventions and their resulting outcomes for which the pharmacist is accountable. Acceptance of this process establishes new goals and allows consideration of educational models developed in other health care disciplines. This paper describes the rationale, format, and process for development of a PBL educational model using a simulated practice-based approach incorporating pharmaceutical diagnosis.

PROBLEM-BASED LEARNING
Problem-based learning, originally developed in McMaster University’s medical school, has gained wide-spread recog-
nition(4), and several medical schools in North America have actively embraced it within their curricula. The McMaster PBL philosophy incorporates the analysis of health care problems as the primary method for acquiring and applying knowledge. Using small groups of five to six students and a faculty tutor as the central educational event, the model divides self-directed learning into eight basic phases. The faculty tutor is present at all group activities and functions as both a subject specialist and trained facilitator to monitor, assess, and provide immediate feedback to the group. This problem-based, student-centered format differs from other educational strategies (e.g., the case study method) by presenting the problem first, before students have learned basic science or clinical concepts.

Although numerous learning theories underlying PBL have been proposed, Schmidt(6) cites three principles in support of an information-processing orientation to PBL: (i) prior knowledge—assumes that new learning does not occur in a vacuum and that existing knowledge is used to understand and structure new information. Ausubel’s assimilation theory(7) provides additional support for this founding principle; (ii) encoding specificity—implies that learning is more likely to occur, when the learning situation closely resembles the situation where it will be applied; (iii) elaboration of knowledge—discussion, answering questions, teaching peers, and critiquing, collectively referred to as elaboration of knowledge, facilitates student understanding of the subject matter.

These principles, as well as other theoretical models(8,9), strongly suggest that the type of problems presented to students serve an important role in the PBL process. According to Wilkerson et al.(10), it is crucial to PBL that “the problem raise compelling issues for new learning and that students have an opportunity to become involved in the discussion of these issues.” Thus, problem structure is an important consideration in designing effective PBL strategies.

PROBLEM STRUCTURE

Problem structure(11), the degree to which a problem can be described and solved, is best depicted by a continuum in which well-structured and ill-structured problems represent opposite ends of the spectrum. Well-structured problems can be described with a high degree of completeness and solved with a high degree of certainty. Presented with a well-structured problem (e.g., solving for an unknown in an algebraic equation), experts will usually agree on a correct solution. The educational goal is usually to deduce correct solutions.

Conversely, ill-structured problems (ignore the negative connotation!) cannot be stated with a high degree of completeness or resolved with a high degree of certainty. Experts may frequently disagree on the best solution, for example, designing therapy for a complicated hypertensive patient. The educational goals of ill-structured problems are to construct and defend reasonable solutions. Problem resolution is far more complex and does not respond to application of a simple algorithm.

Frederiksen(12) identified an intermediate category, which he termed “structured problems requiring productive thinking.” These problems fall closer to well-structured problems and are often useful for ascertaining competency. In this problem type, a crucial step necessary for solving the problem must be generated (i.e., productive thinking).

As King, et al.(11) assert, “if educators neglect to engage students meaningfully in addressing ill-structured problems, the teaching and evaluation of critical thinking skills will also be neglected.” Thus, problem structure is inherently linked to critical thinking, and PBL courses must incorporate ill-structured problems to achieve optimum development of critical thinking skills(13).

PBL IN PHARMACY SCHOOLS

Several curricular innovations in pharmacy schools have utilized PBL methods to teach pharmacotherapy, pharmacokinetics, and diabetes among others(14-17). These examples closely resemble a modified version of PBL, known as “guided design,” which has been recently described at professional and educational meetings(18,19). Originally developed by Wales and Stager(20) for engineering, this method incorporates programmed learning principles (i.e., information-question-feedback) to enhance critical thinking. Using guided design, the instructor breaks each problem into several problem-solving stages and prepares written and/or verbal feedback for each stage. Small student groups collectively work through the problem and are provided with immediate feed-back after each step to evaluate their progress.

Although pharmacy-based PBL methods are diverse and uniquely tailored to individual course objectives, these examples typically present relevant patient information while asking relatively well-structured questions. Since most pertinent data is voluntarily presented, the emphasis is directed primarily at data analysis. Therefore, these examples appear to more closely resemble Frederiksen’s structured problems requiring productive thinking. While they clearly represent valuable contributions to pharmacy PBL curricula, additional models incorporating ill-structured problems are necessary to further enhance development of critical thinking skills.

THE IDAHO STATE UNIVERSITY MODEL

The ISU curriculum is based upon the PBL process originally developed by Barrows et al.(21), for use in medicine, and is adapted to emphasize the fundamental concepts of pharmaceutical diagnosis and its application to pharmaceutical care. The primary objectives of the PBL courses are to: (i) emphasize fundamental basic science concepts; (ii) provide a structure and process for clinical problem-solving; (iii) allow students to develop these skills prior to actual patient or health care provider interaction; (iv) foster development of team-oriented interactive communication skills; and (v) instill attributes and skills for life-long, self-directed learning. These required courses constitute two credit hours each semester during the second and third professional years of our entry-level PharmD curriculum (i.e., four semester sequence). While it is important to emphasize that our PBL courses do not entirely fulfill the requirements for problem-based learning as defined by the McMaster model, much of the underlying philosophy and process is present.

First year basic science courses (anatomy, physiology, biochemistry, immunology, microbiology, and clinical chemistry) are the only didactic coursework taught prior to PBL. Beginning in the second professional year, PBL is initiated concurrently with pathophysiology, pharmaceutics, and pharmacology. Patient cases are selected from several major content areas within these disciplines (e.g., CHF, diabetes, Parkinsonism). Facilitators at this level focus on rel-
evant basic science concepts within each case, reinforcing content from didactic coursework. The courses are designed to facilitate an in-depth understanding of the underlying basic science mechanisms responsible for all patient problems and suggest potential drug therapies.

During the third year PBL courses, patient cases parallel the lecture sequence in Therapeutics although complete congruence is impossible (i.e., not all therapeutics topics are represented in the PBL cases). Since an appropriate pharmaceutical diagnosis (or diagnoses) by design implies a limited number of rational therapeutic alternatives, significant emphasis is given to the diagnostic process during the third year PBL courses. Using a clinical problem-solving structure identical to that employed in medicine, students develop a comprehensive pharmaceutical care plan when the group is confident all problems have been identified and a rational therapeutic plan has been developed. To gain a better understanding, a description of the structure, process, content and evaluation method is necessary.

PBL Structure
The course format generally utilizes a patient problem but could also incorporate a health care delivery problem or research problem as a stimulus for learning in selected areas. Tutorial sessions consisting of 5-6 students are presented with the patient’s chief complaint as the only introductory information offered. To obtain additional information, students must ask questions regarding: lifestyle habits, psychosocial history, medication history, past medical history, determine the presence (or absence) of specific symptoms, and obtain results of physical examinations and laboratory test information. Questions may be asked in any form and any sequence desired. Answers are generated from a casebook containing 212 standardized patient history information items, 121 physical examination procedures, and 359 laboratory or diagnostic tests.

Although designing and producing PBL patient case materials presents important work-load considerations, the use of a computer-generated template to construct the patient case booklets substantially minimizes the effort required. The template consists of a set of normal responses for all clinical history information and normal test results for all physical examination and laboratory test information. Questions may be asked in any form and any sequence desired. Answers are generated from a casebook containing 212 standardized patient history information items, 121 physical examination procedures, and 359 laboratory or diagnostic tests.

Group Selection. Several approaches have been used to place students into groups. Self selection was not a good alternative supporting the old cliche “like attracts like”. Currently, student groups are assigned in order to achieve a similar grade point average between all groups. Students are maintained in their respective groups throughout the first and second semesters and randomly assigned to new groups in the third and fourth semester PBL courses.

Resources. Since PBL instruction is best held in small class rooms where students can sit around a table, identifying appropriate classroom space is an important resource consideration. Substantial effort was placed in scheduling the PBL courses in order to minimize the number of small classrooms required, and our current structure utilizes only five rooms during any two hour time block.

Since the ability to identify appropriate information resources is an important goal, a wide variety and greater number of reference materials are necessary. Multiple sets of standard medical compendia including textbooks of clinical laboratory medicine, pathophysiology, physical assessment, therapeutics, and several internal medicine texts, two networked drug information databases, as well as numerous other secondary references are readily accessible for student use within the classrooms. Additionally, students are expected to identify and bring in other reference material they find useful. To accomplish this, students spend significantly greater time utilizing the medical library than had previously occurred. While this is a highly desirable outcome, it also poses potential workload considerations for library staff and resources.

Facilitator’s Role
The tutor, or facilitator as we prefer to identify faculty instructors, has several critical tasks to maintain an effective problem-solving process. These include: (i) to keep the process moving, to make sure that no phase is neglected, and that each phase is taken in the right sequence; (ii) to thoroughly probe the student’s knowledge and understanding of the information presented; (iii) to insure that all students are actively engaged in the process; (iv) to constantly monitor the educational progress of each student and identify learning difficulties; (v) to provide a strong stimulus for learning without resorting to a ‘didactic’ role; and (vi) to assist the group in dealing with potential interpersonal problems and group dynamics that may inhibit the process. For more detailed discussion of these topics, readers are referred to the excellent review by Barrow’s(1).

Selection and Training. Faculty from both departments have readily volunteered for the PBL curriculum, finding it both challenging and rewarding. Basic science faculty serve as facilitators for the second year PBL courses while clinical and pharmacy administration faculty are primarily responsible for the third year courses. Facilitator selection is problematic at times, primarily due to variable teaching loads between semesters. Frequent meetings of the tutorial faculty to discuss individual case objectives, maintain consistency between groups, and exchange ideas for teaching enhancement are an essential component of on-going facilitator training. New faculty coming into the course for the first time generally sit with an experienced facilitator to observe the process and assessment methods. They are also encouraged to read relevant reference materials (1, 21, 23).

Process and Content
Tutorial sessions meet twice weekly for two hours although considerable outside time and effort is required. Working collectively, students “interview the patient” (i.e., via responses obtained from the casebook), share knowledge, identify potential hypotheses, and determine the appropriate data necessary for accurate and thorough pharmaceutical diagnosis. Although the amount of class time devoted to each case varies, 5-6 class periods (i.e., about three weeks) is typically allotted.

The clinical problem-solving process is based on nine stages described by Barrows, et al. (Figure 1) and is analogous to the medical model(21). The underlying premise in this model asserts that all drug-related problems are the pharmacist’s responsibility. Thus, the pharmacist’s first responsibility is to ensure all drug-induced patient problems, either real or potential, are appropriately identified and resolved. For our purposes, students must assume that all patient problems are drug-induced until proven otherwise.
Fig. 1. Theoretical model for drug-related problem-solving (adopted from ref. 21).

(i.e., all potential drug-induced etiologies must be ruled-out through a hypothetical-deductive reasoning process identical to medical diagnosis). This process is designed to arrive at an appropriate pharmaceutical diagnosis as depicted in Figure 1.

In contrast, physicians generally tend to prioritize pathological over pharmacological causes of disease. Thus, medical and pharmaceutical diagnosis can be viewed as complimentary, but uniquely distinct perspectives. Theoretically, this model offers a clinically useful “collaborative diagnostic process” in which a wide spectrum of potential problems are systematically and concurrently investigated by physicians and pharmacists until a true cause is identified. If all drug-induced causes are excluded, a default pharmaceutical diag-
Table I. PBL assessment criteria

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<tr>
<th>Facilitator’s Evaluation Criteria</th>
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<tr>
<td>Ability to frame the problem</td>
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<td>Hypothesis generation</td>
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<tr>
<td>State needed data to solve the problem</td>
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<tr>
<td>Systematically gather and analyze the data</td>
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<tr>
<td>Ability to organize thoughts</td>
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<td>Decision making</td>
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<tr>
<td>Identify knowledge deficiencies</td>
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<td>Self study ability</td>
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<td>Communication ability</td>
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<td>Identify factors leading to alternate solutions</td>
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<tr>
<th>Student Peer Group Evaluation Criteria</th>
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<tr>
<td>Student’s contribution to the group learning process</td>
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<tr>
<td>Student appropriately questions classmates</td>
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<tr>
<td>Student actively participates as a member of the team</td>
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<tr>
<td>Student demonstrates effective communication</td>
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<tr>
<td>Student provides adequate supporting arguments, evidence, examples, and details</td>
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...nosis of “possible new therapeutic problem” is implied and a physician’s medical diagnosis is required. Perhaps in time, the reverse scenario is also possible!

Certainly, the model we have described provides a significantly different philosophical approach to patient care than is generally prevalent in pharmacy practice today. Nevertheless, it provides a practical methodology for efficiently differentiating physician versus pharmacist responsibilities. Although the professional viability of pharmaceutical diagnosis remains to be established, its contribution to enhancing student understanding and appreciation for pharmacists’ responsibilities under pharmaceutical care is significant. Extracted portions of an original PBL case are provided to illustrate the process.

Patient and Situation (Step 1)

As previously described, the patient’s presenting or chief complaint is the only information voluntarily presented to the student group. This may include the patient’s photograph, but all other information must be collected via student generated questions. From the initial presentation, clues to the nature of the problem are established. Excerpted portions of Commodore Sloan’s case are presented in Appendix A (Commodore Sloan, is a 63 year old WM, who presents to the ER with nausea, vomiting and anorexia for the past two weeks).

Hypothesis Generation (Step 2)

The group attempts to generate as many ideas about the possible causes or explanations from the available clues. No restraint is placed on the creative process. All ideas (including bizarre ones) are recorded as hypotheses. However, since a new therapeutic problem is always a possibility, all etiologies, including potentially undiagnosed medical problems, must be considered. (Preliminary Hypotheses include: adverse drug reaction, drug-drug interaction, drug-disease interaction, GI problem, carcinoma, CNS infection, psychiatric problem, AIDs, etc.).

Inquiry (Step 3)

The generated hypotheses dictate the future course of action. After consideration of the initial hypotheses, an inquiry strategy is formulated by the group. Students are encouraged to develop a systematic inquiry strategy that explores and describes all parameters of the patient’s symptoms (e.g., onset, duration, progression, associated symptoms, aggravating/ alleviating factors, etc.). In this manner, the group develops a universally applicable inquiry strategy that parallels the medical history-taking process employed by physicians. This is deemed important for two reasons: (i) to ensure students are able to function in a primary care role where nearly all history and clinical information must be obtained from the patient (e.g., community practice) and (ii) to ensure students are able to determine when important information relating to potential pharmaceutical diagnoses is missing from the medical record.

Data Analysis (Step 4)

Each new item of information gained, from the inquiry process, is tested against the recorded hypotheses and a pharmaceutical differential diagnosis is generated at this stage. At least ten pharmaceutical diagnoses must be considered in the case of Commodore Sloan and a partial list of differential diagnoses that must be confirmed or ruled out include (see Table 1—preceding manuscript for definitions of diagnostic labels):

- $D_1$: R/O adverse drug reaction, (digoxin)
- $D_2$: R/O drug-drug interaction, (digoxin-HCTZ)
- $D_3$: R/O pharmacokinetic interaction, (compromised elimination of renally excreted, drugs)
- $D_4$: R/O suboptimal therapeutic response (CHF)
- $D_5$: R/O drug-disease interaction; (alcoholism-digoxin)

Thorough data collection and analysis should enable students to rule out several other potential diagnoses (e.g., psychiatric problem, CNS infection, and history of trauma), strengthen existing ones (e.g., a digoxin drug-related problem), or generate new hypotheses.

Inquiry (Repeat Step 3)

Several lines of inquiry may be necessary to elicit a thorough and accurate history. Using the generated differential diagnoses, the facilitator challenges the students to justify each piece of physical examination and laboratory test information needed to confirm or reject their hypotheses. In the example case, information from the physical examination is necessary to exclude the presence of a mass and lymphadenopathy as well as document the presence of hepatomegaly and grade III CHF, etc.

Problem Synthesis (Step 5)

Establishing a clear mental representation of the problem is emphasized in this step. With new information gained from inquiry, the relevant diagnoses are now organized and a hierarchical order is established. Of course, new hypotheses can be added at any time. This organization is recorded and a student at random may be asked to summarize the case. Summarization is an important process that facilitates keeping the group on track and ensures existence of an adequate mental picture and appropriate organization of the patient’s problems.

Commitment to the Cause of the Clinical Problem (Step 6)

From the available information, each group member must now commit to the cause(s) of the patient’s problems and establish an appropriately stated pharmaceutical diagnosis. Although a consensus may be achieved, the views can be as diverse as the group size. This exercise provides strong motivation for self-learning.

In the example case, at least five confirmed pharmaceutical diagnoses are present. Although digoxin toxicity is easily identifiable as the primary DRP, at least two factors are contributing influences. An accurate pharmaceutical diagnosis will appropriately identify all problems and, more
importantly, will assist the student in designing a rational therapeutic solution.

**PharmDx #1:** drug-disease interaction (digoxin) due to alcoholism-induced hypomagnesemia manifested as anorexia, nausea and vomiting.

**PharmDx #2:** drug-drug interaction (digoxin-HCTZ) due to thiazide enhanced hypomagnesemia (complicating #1) manifested as anorexia, nausea and vomiting.

**Concurrent Problem-Solving Phases**

**Identifying Learning Issues.** This stage begins during the hypothesis generation stage and continues throughout. The group identifies issues pertinent to the patient’s problem and assigns each member a topic to research and present for discussion. Students are encouraged to talk to practitioners, content experts and other faculty members as part of their professional socialization. The facilitator’s role is extremely important during this process and seeks to: encourage students to take on unfamiliar issues, challenge their understanding of the topics, and assist students in improving their clinical reasoning skills. (Learning issues include but are not limited to: the role of hypomagnesemia in digoxin toxicity, therapeutic considerations with concurrent digoxin and thiazide diuretic use, pathophysiology of CHF and alcoholism, digoxin pharmacokinetics, etc.).

**Identify the Learning Resources.** Before any library research is initiated, students must identify potentially useful resources. This approach facilitates student understanding of the value and role of primary and secondary information resources. Validity of the resources actually used to solve the case is an important assessment criterion.

**Self-Directed Learning.** Self-directed learning is an essential part of the PBL process and attempts to motivate students by, first, challenging them to identify knowledge deficiencies and then formulating a strategy to master the information. During this process, additional issues may arise which require further review, and the cycle is reinitiated. Ultimately, the application of new learning to the problem facilitates a deeper understanding and better integration of the information.

Oral presentation of learning issues provides students with an opportunity to demonstrate competency, gain self-confidence, and refine communication skills critical for their role as practitioners and counselors. The ability to initiate development of these skills prior to clerkship entry is a significant advantage afforded through the student-centered tutorial process.

Unfortunately, self-directed learning is virtually ignored in most curricula, and students are generally left to self-discovery of these essential skills. The ability to identify and resolve knowledge deficiencies is, nevertheless, a skill that requires significant self-awareness, an inquisitive nature, and most importantly, frequent practice. The PBL tutorial is ideally suited for emulating and refining these abilities and provides an opportunity to instill the need for life-long learning.

**Pharmaceutical Care Plan**

After commitment to a pharmaceutical diagnosis (or diagnoses), students in the third year PBL courses are required to complete a pharmaceutical care plan. The pharmaceutical care plan is heavily anchored to the Pharmacist’s Work-up of Drug Therapy (PWDT)(22) and is a concerted effort to simulate clerkship expectations as closely as possible. Phase two of clinical problem-solving (see Figure 1) incorporates a similar process of hypothesis generation, inquiry, and data analysis as performed during the diagnostic phase. Although additional patient data may be required during this phase, much of the inquiry and data analysis focuses on drug information and therapeutic issues. Student learning issues generally involve integration of a therapeutic knowledge base as it applies to a specific patient. Patient-specific information, collected during the diagnostic phase, is systematically evaluated in an attempt to arrive at a patient specific treatment regimen to resolve each identified pharmaceutical problem. Students cycle through an iterative problem-solving process to identify pharmaceutical diagnoses, determine patient-specific therapeutic drug regimens, define appropriate therapeutic monitoring parameters, and document patient education strategies. Initially, the student pharmaceutical care work-up represents a relatively detailed and comprehensive format similar to that established by Strand et al.(22). Over the last two PBL semesters, the written care plan evolves to a more clinically relevant documentation form (e.g., a modified SOAP note). Thus, the structural process for developing a comprehensive pharmaceutical care plan remains the same regardless of patient type or problem encountered. Appendix B illustrates the case report form initially required of third year students.

**Assessment**

The importance placed on PBL is evidenced by the evaluation philosophy, which is significantly different from any other course in the professional curriculum. Students are awarded a passing letter grade (i.e., A, B, C) or remediate. In practical terms, this means each student must demonstrate the desirable PBL competencies before they may enter the clerkship program. Moreover, it allows academic progression to be halted, regardless of academic standing, if minimum competency is not demonstrated. Evaluation is based on three separate assessments for each case: a facilitator’s assessment, student self-assessment, and peer group assessment.

**Second Year Assessment.** Facilitator and self assessments are based on a four point scale (i.e., five ordered categories ranging from 0 = poor to 4 = exceptional). Facilitators meet individually with students to review their respective self and peer assessments. However, the individual case grades are based only on the facilitator’s average score for performance in ten criteria (Table I). Because of potential grading bias between individual facilitators, attempts are made to rotate every group through each facilitator.

Using a similar four point scale, each student evaluates their respective group members on the five criteria listed in Table I. Total points awarded to the group is limited according to the following formula: (total points = 4 x (# students in the group -1) + 2). This method effectively prohibits a maximum point award for all group members and requires students to make critical decisions relative to peer contributions and performance in the case.

**Third Year Assessment.** Assessing student performance is very similar, by design, to the experiential evaluation process. Therefore, PBL assessment is an opportunity to introduce students to a competency-based format similar to that employed in the clerkship curriculum.

In addition to similar student assessment activities, a critical evaluation of the pharmaceutical care plan is com-
completed by the facilitator. The relative weights assigned to third year PBL assessments include: peer evaluated group participation (15 percent), written pharmaceutical care plan (40 percent), and examinations (45 percent). The examinations are heavily weighted to emphasize the importance of individual skill development. For examination purposes, students must independently work through a computer-based version of the PBL process and submit a written pharmaceutical care plan.

The computer cases, partially developed through an American Association of Colleges of Pharmacy’s (AACP) Innovations in Teaching Award, were originally designed for use in our Nontraditional PharmD program. However, they have proven quite useful as a PBL examination method also. Interested individuals may gain a greater appreciation for the process by reviewing a sample computer case. To gain access through the Internet, direct any web browser to: http://pharmacy.isu.edu/case/study. When prompted, enter “guest” for both the username and password. After reviewing the instructions, click on the case of Ryan Nadle and proceed. Use of the computer cases allows the clinical and patient information requested by each student to be individually tracked. Hopefully with experience, use of the computer cases may facilitate an ability to detect and correct cognitive reasoning problems.

CHALLENGES
In a review of the PBL literature between 1972 and 1992, Albanese and Mitchell(4) raise several challenges facing the implementation and educational effectiveness of PBL including: (i) the cost of PBL delivery compared to conventional lecture based instruction; (ii) the possibility of PBL to weaken other aspects of cognitive-processing; (iii) whether PBL provides delivery of content material in sufficient breadth and depth; and (iv) whether students may become dependent on the group process? While readers are strongly encouraged to review Albanese and Mitchell’s excellent discussion of these topics, some brief comments based upon our experience may be worthwhile. Certainly, our intent would be to provide future justification for PBL methods through carefully designed evaluations and additional reports in the Journal.

PBL curricula involve substantial faculty time and resources. Approximately 16-18 faculty (i.e., our class size is approximately 50 students/year) are required each semester to provide optimal support for the PBL sections. Admittedly, finding enough facilitators to achieve groups of 5-6 students is difficult. However, just as faculty abilities differ with respect to didactic lecture skills, facilitators are similarly variable. Thus, the potential exists to tailor faculty skills to the unique attributes required of tutorial versus classroom teaching. Furthermore, the diversity of effective facilitators need not be limited to full-time faculty, but may include carefully selected graduate students, residents, practitioners, and perhaps eventually senior students. Other potential methods have been recently described(23).

The cost-benefit of such intense educational resource utilization is certainly an important issue requiring additional study. Unquestionably, didactic lecture based instruction is an extremely efficient method for delivery of content material. While most studies suggest PBL curricula require significantly more time to cover the same content, the majority of faculty time is spent engaged in direct student contact while traditional didactic teaching is devoted primarily to lecture preparation(20).

From the beginning, our approach has been an attempt to optimize both teaching methods. As stated previously, the primary objective was to foster and develop a clinical problem-solving process beginning at an early point in the pharmacy curriculum, and secondly, to use the PBL case problems to reinforce important didactic content areas. This philosophical approach simultaneously addresses the issue of breadth versus depth of content material and within our curriculum serves the purpose of “student-centered, problem-based variations of recitation courses” where integration of the entire curriculum occurs (i.e., “any problem is fair game”). Thus, ISU differs substantially from typical PBL models in that we have not attempted to replace didactic teaching with PBL, but rather to balance the strengths of both didactic and PBL teaching methods. While some PBL authorities argue against this dual method approach, in our experience, it has proven successful.

The potential to over-emphasize group problem solving abilities at the expense of other cognitive processing skills is a concern. Students quickly learn to utilize their collective talents to solve problems. However, this reliance on the group may not appropriately facilitate development of all necessary cognitive skills required of an individual practitioner. Similarly, the ability of PBL to foster mastery of important information is complicated by the group process. Because problems are solved by dividing the work (i.e., learning issues) and reporting information back to the group, individual members may learn only one aspect of the case in depth. In an attempt to at least partially resolve these problems, we have begun to supplement group work-ups with cases in which students provide their own independently derived case work-up. Unequivocally, continuing to refine PBL methods to further enhance student critical thinking skills and effective self-learning strategies is an important area of scholarly pursuit for pharmacy educators.

Student concerns have centered primarily around two issues. First, two credit hours per semester is not consistent with the amount of work required of these courses. In their view, significantly more effort is required for the PBL courses than other two credit courses in the curriculum. Second, students are concerned that demands and expectations of individual facilitators vary considerably. Both probably have some degree of validity but are correctable with continued effort. Nevertheless, students overwhelmingly support the PBL curriculum and rate it as one of the more valuable contributions to their educational and professional development.

Finally, schools considering PBL enhancements of similar design must consider where they will find room in an already intense professional curriculum. In our case, the addition of eight semester credits of PBL was attained by a reduction in didactic credit hours accomplished through integration of several didactic courses and a modest increase in total credit hours. Although painful, the reduction in didactic credit hours was justified on the basis of enhanced coverage of important topics within the PBL courses.

SUMMARY
Motivation to learn is an essential element and is derived through working with an unknown, but real patient problem. Students must actively seek information, look for clues,
gather and analyze data, develop hypotheses, and apply deductive reasoning skills to solve problems. Thus, the clinical reasoning process closely resembles that used in medicine. By encountering ill-structured problems, students acquire an integrated knowledge base and enhance their critical thinking skills. The ISU model, which incorporates pharmaceutical diagnosis as an integral step, is designed to prepare students to generate and defend reasonable therapeutic solutions to active or potential DRPs.

Am. J. Pharm. Educ., 61, 18-26(1997); received 10/15/96, accepted 1/10/97.

References
(16) Simms P.J., “Utilizing the peer group method with case studies to teach pharmacokinetics,” ibid., 58, 73—77(1994).

APPENDIX A. EXCERPTED EXAMPLES OF COMMODORE SLOAN CASE

Presenting Problem Queries
Q1-1: How/when did the problem start?
Q1-4: What makes the problem or symptoms worse?

Specific Symptom Questions
Q2-26: Chest pain?
Q2-58: Dizziness?

Habits & Lifestyle Questions
Q3-167: Tobacco use

Past Medical History
Q4-174: Current medications

Psychosocial History Questions
Q5-191: Average daily activities

Physical Exam
E41: Extremities

Laboratory Exams
TI-67: Magnesium 0.78 mmol/1
TI-81: Therapeutic drug level 0.78 mmol/1

APPENDIX B. PATIENT WORK-UP FOR THIRD YEAR PBL COURSE

A. Presenting Problem (5 points)
Signs/Symptoms:
Current Medication List

B. Initial Hypotheses (5 points)
Hypotheses:
Systems Involved:

C. Medical Diagnosis (10 points)—List patient’s medical problems in order of significance and provide justification for your decision (i.e., give significant medical history, exam results, laboratory tests or any other pertinent information that supports the diagnosis).

Medical Problem#1:
Medical Hx:
Physical Exam: Laboratory/Dx Tests:
Laboratory/Dx Tests:
D. Pharmaceutical Diagnosis (20 points)—List the patient’s pharmaceutical diagnosis (PharmDx) in order of significance.

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<tr>
<th>Diagnostic label Due to (etiology/mech.)</th>
<th>Manifestations</th>
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E. Therapeutic Recommendations (15 points)—State the patient-specific treatment regimen for each pharm. diagnosis listed above. Each dx may have more than one drug therapy or may require discontinuation of current therapy. You must take into account patients individual characteristics (i.e., economic status, quality of life, age, sex, etc.) and potential drug interactions. Remember, you are treating a patient, not a disease.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
<th>Schedule</th>
<th>Route</th>
<th>Duration</th>
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F. Rationale (15 points)—For each pharm. dx, justify your decision for the therapeutic regimen chosen. This frequently necessitates supporting literature (reference section) including: randomized, controlled clinical trials, consensus panel recommendations, or a meta-analysis. Your rationale should also include patient specific characteristics that influenced your decision. Please also include an alternative therapy.

References (5 points):

G. Monitoring Plan (15 points)—What do you want to have monitored, how often and for how long? The question you must ask is “How will I know if my recommendations actually solve or prevent this patient’s pharmaceutical diagnosis?”

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target goal or range</th>
<th>Frequency</th>
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2.  

H. Educational Plan (10 points)—What does my patient need to know about their condition, therapy, or monitoring?