Design of a problem-based undergraduate course in pharmacology: implications for the teaching of physiology

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RANGACHARI, P. K. Design of a problem-based undergraduate course in pharmacology: implications for the teaching of physiology. Am. J. Physiol. 260 (Adv. Physiol. Educ. 5): S14–S21, 1991.—University learning can be either teacher centered or student centered. Problem-based self-directed learning in the context of small groups provides students with an opportunity to take greater responsibility for their own learning. In problem-based learning, process and content are inextricably linked, with the three cardinal elements being the students, the tutors, and the problems. The design of such an undergraduate course in pharmacology is described, and the implications for teaching physiology are discussed.

TEACHER-CENTERED LEARNING is the norm in undergraduate science courses. The lecture hall is the forum where predigested information is delivered, sometimes effectively, to a largely passive audience. From the perspective of university administrators and faculty, this is an efficient process. The teacher, having prepared a set of notes, can deliver lectures year after year with minor revisions, leaving ample time for research that often brings dollars into the university’s coffers. The fact that students may think otherwise is felt to be of little significance. In contrast to this convenient method of instruction is the polar opposite belief, that students may actually be able to learn quite effectively on their own, given the right environment. This format is messy, smacks of curricular chaos, and requires more contact hours between faculty and students. In its most paradigmatic form, it is referred to as problem-based learning (1–3, 8, 9, 11–14, 17–20, 22–24), although it is perhaps more aptly described as student-centered learning.

The use of the term problem-based learning appears to vary widely (1–3, 9, 18, 19, 22, 23). The Handbook for Tutors (8) used in the Faculty of Medicine at the University of Western Ontario describes problem-based learning as

an approach to learning and teaching that begins with puzzling problematic situations first. This contrasts with subject-based approaches where students are first taught a body of knowledge and then may have an opportunity to apply what they have learned to sample problems. Finding the right answer to a problem or applying what has already been learned to a problem is not problem-based learning. In PBL [problem-based learning], the “problem” serves as a stimulus and focus for students to identify what they need to learn in order to understand the problem and also to learn about the broader concepts and principles related to the problem.

This latter point is worth emphasizing, and thus problem-based learning is quite distinct from the patient-oriented problem-solving systems that have been developed for use in subjects such as pharmacology or immunology (4). The problem is used as a springboard for learning, and the more appropriate term for this form of learning would be “contextual learning” (11). Although a number of medical schools have adopted problem-based learning, differences in implementation clearly exist. In a recent study, Blumberg et al. (2) compared seven medical schools in North America and noted differences even with a single issue, such as student-generated learning issues. The schools studied were Bowman Gray, Harvard, Mercer, Michigan State, Rusk, University of New Mexico, and McMaster.

The objective of this paper is to describe the design of a student-centered problem-based course in an undergraduate program that was organized in a small-group tutorial format. Using that particular example, I discuss the promises and pitfalls of such approaches and emphasize its implications for the teaching of physiology.

In the context in which I discuss this approach, there are three cardinal elements to problem-based learning: 1) the students, 2) the tutors, and 3) the problems (Fig. 1). It is the dynamic interactions between these three elements that determine the success or failure of the method. In this form of learning, process and content are inextricably linked.

The term “process” refers to the “how” of problem-based learning. It includes the means by which issues are raised, identified, and refined into learning tasks and the required information is sought, analyzed, assimilated, and shared. Successful practice requires that the students critically evaluate their own performance and that of their peers and tutors. This evaluation is included in the term process. Content refers to “what” is learned and corresponds to the subject matter of the course. Although there could be a separation for analytical purposes, it is important to realize that what is learned effectively stems from how it is learned. Problem-based learning thus represents a dialogue between process and content.

In setting objectives for a problem-based course, it is important to include both “process” and “content” objectives. Students must be expected to meet essential proc-
ess requirements that include the elements listed above. Content objectives can be listed as “instructional” and “expressive.” The latter is particularly important for a problem-based course. An expressive objective, notes Eisner (7), does not specify the behaviour the student is to acquire after having engaged in one or more learning activities ... [it] describes an educational encounter ... provides both the teacher and the student an invitation to explore, defer or focus on issues that are of peculiar interest or import to the enquirer. An expressive objective is evocative rather than prescriptive.

Another term worth clarifying is “self-directed learning.” Branda (3) has emphasized that self-directed learning is an integral part of problem-based learning, although it can occur on its own. Self-directed learning is not synonymous with self-indulgent or self-willed learning. Objectives clearly exist. It is akin to defining a spot on a map that students are expected to reach, without specifying the routes involved. Self-direction involves defining the most appropriate path for an individual student to attain the stated objectives.

DESIGN OF THE COURSE

For those unfamiliar with the process as practiced at McMaster University, I give a brief description based on the undergraduate course in pharmacology mentioned above. This course formed part of a new joint Honours Programme in Biology-Pharmacology recently introduced as a joint responsibility of the Department of Life Sciences and the Faculty of Health Sciences. It was decided at the outset that most courses will be offered in a problem-based format. There was a cooperative component to the program with the students completing work terms either in industrial or academic laboratories during the course of the 3-yr program. Sixteen students were selected on the basis of an individual letter of application followed by an interview. These students were divided into three groups at random. The introductory course ran for the entire academic year, i.e., 24 wk. Each group met with their respective tutors once a week for a 3-h period. The students remained in the same group for the entire period, but a different set of tutors took over at the end of the first 12 wk. This was done for logistical reasons, since the tutors had prior commitments. However, for the sake of continuity, the first set of tutors remained accessible to their group. The tutors selected were not only experienced tutors but also had research interests in different areas of pharmacology and physiology.

OBJECTIVES

The objectives of the course were essentially twofold: 1) to introduce the students to key concepts in pharmacology to prepare them for their work terms as well as for more specialized courses in later years and 2) to facilitate transfer to a self-directed style of learning.

The pharmacological issues dealt with in this course included, among others, drug receptors, agonism, antagonism, pharmacokinetics, biotransformation, bioavailability, environmental pollutants, autonomic receptors, drug interactions, drug abuse, street drugs, steroids, design of clinical trials, etc. These issues were encapsulated in carefully written paper problems that had, as their basis, hypothetical experimental situations, clinical scenarios, or excerpts from published material. With each problem, a set of minimal objectives (instructional objectives) was defined that were felt to be essential, and it was expected that all groups would meet these objectives. However, students were at liberty to explore other issues and were in fact actively encouraged to do so (expressive objectives). The problems were not meant to be solved in the conventional sense but acted merely as starting points for explorations. The summaries of the nine problems that were used along with the minimal objectives are listed in Table 1. It is interesting to compare these objectives with those listed by Burks (5) as part of a general pharmacology course.

The second objective of facilitating transfer to a self-directed style was crucial, since most students were accustomed to teacher-centered didactic systems of learning. In this format, the students had to accept greater responsibility for their own learning, with the tutors acting largely as guides and being resources only when requested.

TUTORIAL PROCESS

Presented with a given problem, the students engaged in an initial period of brainstorming (1–3, 8, 14, 16–18). The objective of this phase was to provide a forum for the generation of ideas unhindered by critical judgments as to the relative value of the suggestions made. It must be emphasized that these students had received no formal lectures on these subjects nor had they been presented with required reading before the problem was given. It was felt that doing the problem “cold” permitted a freer flow of ideas. The prescribed minimal objectives were not given to the students at this stage. The brainstorming sessions were followed by an attempt to generate some order out of this apparent “curricular chaos” (13). This consisted of refining the ideas and suggestions to be made into issues for learning. The tutor acted as a facilitator and ensured that participation was even. The learning issues provided a framework for further refinement into learning objectives. At this stage, the tutors had to judge whether to provide the students with the set of minimal objectives. As a rule, students had not only raised the expected issues themselves but also had
began raising a number of issues. The issues that they felt were worth noting on the board are listed as the broader environmental issues as well.

As is evident from a cursory glance, there are redundancies in the issues listed, but at this stage no real critical evaluation occurred. Then began a period of negotiation between the students as to the relative importance of the issues raised. Their goal was to prune these issues into learning objectives. These refined learning objectives are listed as well.

It is interesting to note that the objective of this exercise from the planner's point of view was to introduce the students to the concepts underlying biotransformation of drugs and the implications of environmental pollution. The faculty-generated objectives are also listed for comparative purposes. Thus the students came up with learning objectives that were not substantially different from those prescribed and in the process of seeking out the information, covered all the items stated.

As mentioned above, the students were expected to submit a written summary of tutorial discussions as well as a miniessay on any issue that was of particular interest. Although the students embraced this exercise from the planner's point of view was to introduce the students to the concepts underlying biotransformation of drugs and the implications of environmental pollution. The faculty-generated objectives are also listed for comparative purposes. Thus the students came up with learning objectives that were not substantially different from those prescribed and in the process of seeking out the information, covered all the items stated.

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idea in principle, it became difficult to institute in practice, and considerable variability was noted between tutorial groups. Some students used this opportunity to critically assess a research paper, an exercise they had not done before; others reviewed specific areas; and some handed in essays of a more general nature. It was clear that in the future stricter guidelines should be adopted. Class participation was evaluated at the end of each tutorial as well as at the end of the terms. Students evaluated each other, and these evaluations were counted as equivalent to those of the tutors; this was a novel experience for the students, but it was surprising how quickly they adapted. The students became more comfortable with this process with time, and their evaluations of their peers were rarely different from those of the tutors.

A formal evaluation procedure was required to satisfy university requirements. We designed a process-oriented procedure termed the group triple-jump exercise based on the individual exercises used in the medical and nursing program at McMaster University (6, 15). In this exercise, all 17 students met in the same room and were handed a paper problem that none of them had seen earlier. The students had 15 min to provide one to three explanations for the observations made. They were then given a further 15 min to choose one of the explanations offered and design a suitable experimental test. At the end of this period, they handed their answers in and were then given a set of reading material that provided further information on the problem at hand. They were asked to reassess their initial hypotheses/experimental tests in light of the new information provided and submit a written report in 2 h. This procedure attempted to test the students on hypothesis generation, the design of experimental tests, and their ability to reassess, synthesize, and assimilate new information. Although the students met together and the same problem was given to all, the assessments were individual. The emphasis was on the process of learning, although clearly students who had not assimilated pharmacological information adequately could not generate either credible hypotheses or propose experimental tests. Content was assessed on an ongoing basis by tutorial performances and the written reports. The students thoroughly enjoyed this approach,

### TABLE 2. Sample problem

<table>
<thead>
<tr>
<th>Initial Issues Raised by Students</th>
<th>Refined Student-Generated Learning Objectives</th>
<th>Faculty-Generated Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) What causes asthma?</td>
<td>1) Mechanisms of tolerance to theophylline and alcohol</td>
<td>1) Biotransformation of drugs</td>
</tr>
<tr>
<td>2) Why does the dose of theophylline increase? Is it tachyphylaxis?</td>
<td>2) The role of metabolism in drug action (biotransformation, focusing on theophylline and alcohol)</td>
<td>2) The central role of liver enzymes</td>
</tr>
<tr>
<td>3) How does theophylline work? Why is it given to asthmatics?</td>
<td>3) The use of theophylline in asthma</td>
<td>3) Cytochrome-P&lt;sub&gt;450&lt;/sub&gt;</td>
</tr>
<tr>
<td>4) Why is there an increase in cancer?</td>
<td>4) The design of a study to assess tolerance to theophylline in the population of asthmatics on the island</td>
<td>4) Enzyme induction by drugs</td>
</tr>
<tr>
<td>5) What causes cancer?</td>
<td>5) Problems arising from the eating of contaminated fish, focusing on PCBs</td>
<td>5) Pollutants</td>
</tr>
<tr>
<td>6) Is there a link between cancer in fish and theophylline?</td>
<td></td>
<td>6) The concepts of zero /first order kinetics</td>
</tr>
<tr>
<td>7) Do people eat the fish, and is the food chain important?</td>
<td></td>
<td>7) Differences in the metabolism of alcohol and theophylline</td>
</tr>
<tr>
<td>8) Tolerance: how is it acquired?</td>
<td></td>
<td>8) The toxic effects of PCBs</td>
</tr>
<tr>
<td>9) Are there different types of tolerance to theophylline and alcohol?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10) How does metabolism affect drug action?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Can an increase in metabolism explain tolerance?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12) How can one establish the increase in tolerance suggested?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13) What materials are present in torched cars [polychlorinated biphenyls (PCBs), plastics]? Are these important?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Problem

Twenty years ago, the far-sighted government of the Idyllic Isles decided to keep the environment clean from car exhaust fumes by limiting the number of cars on the island. An individual could only obtain a new car if they produced a document stating that the old car had been torched and dumped in the ocean.

Sara is a young marine biologist attached to a newly established World Health Organization-sponsored Fisheries Research Lab on the island. She finds that the incidence of cancer in a population of red fish around the island is higher than that observed in the same species further out in the ocean. Her husband, Paul, who is an asthmatic, has noticed that the dose of theophylline that he needs to control his asthma has gradually increased since they came to live on the island. Sara's findings on the red fish intrigue Helen, who wonders whether there could be a common link, such as altered metabolism. Sara thinks not. "Last week, Paul was stopped by the cops and had a breath-test done," she tells Helen, "he was most annoyed and wished that he had acquired tolerance to alcohol rather than theophylline!"

Problems arising from the eating of contaminated fish, focusing on PCBs

Refined Student-Generated Learning Objectives

1) Mechanisms of tolerance to theophylline and alcohol
2) The role of metabolism in drug action (biotransformation, focusing on theophylline and alcohol)
3) The use of theophylline in asthma
4) The design of a study to assess tolerance to theophylline in the population of asthmatics on the island
5) Problems arising from the eating of contaminated fish, focusing on PCBs

Faculty-Generated Objectives

1) Biotransformation of drugs
2) The central role of liver enzymes
3) Cytochrome-P<sub>450</sub>
4) Enzyme induction by drugs
5) Pollutants
6) The concepts of zero /first order kinetics
7) Differences in the metabolism of alcohol and theophylline
8) The toxic effects of PCBs
since they actually used the examination period to learn new information.

To assess the students’ reactions to the course, a questionnaire was distributed at the end of the first term. The replies to the questions led the planners to believe that they were on the right track (Table 3). It is interesting to compare the results obtained with the same questionnaire at the end of the second term when the students had another 12 wk of exposure to the process. Overall there appears to be an improvement in the scores, suggesting that the comfort level with this approach was increasing.

The students also evaluated the tutors. They were asked to express their disagreement/agreement on a seven-point scale to a series of statements. The results are shown in Table 4. The evaluations of all six tutors are grouped together; although individual tutors did receive slightly different scores on specific items, there were no overall differences of any major significance.

TABLE 3. Summary of student evaluations of the course

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Term 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>Range</td>
</tr>
<tr>
<td>1) The course helped me understand the scope and domain of pharmacology</td>
<td>6</td>
</tr>
<tr>
<td>2) The course gave us a good introduction to the concept of drug receptors</td>
<td>6</td>
</tr>
<tr>
<td>3) The course helped me understand general principles of pharmacokinetics</td>
<td>6</td>
</tr>
<tr>
<td>4) The course helped me obtain information from a variety of sources</td>
<td>6.5</td>
</tr>
<tr>
<td>5) I was able to synthesize information obtained into a comfortable framework</td>
<td>6</td>
</tr>
<tr>
<td>6) I feel that I can apply the general principles I have learned to other pharmacological problems</td>
<td>6</td>
</tr>
<tr>
<td>7) I am comfortable with working in small groups</td>
<td>6</td>
</tr>
<tr>
<td>8) I do not feel reluctant to confess my ignorance on specific issues</td>
<td>6</td>
</tr>
<tr>
<td>9) I am confident that I can analyze a problem and frame learning objectives</td>
<td>6</td>
</tr>
<tr>
<td>10) I feel comfortable sharing information with others</td>
<td>6</td>
</tr>
<tr>
<td>11) I feel comfortable in soliciting help from my peers</td>
<td>6</td>
</tr>
<tr>
<td>12) I feel comfortable in ignoring my tutor’s existence</td>
<td>6</td>
</tr>
<tr>
<td>13) I can assess my own performance adequately</td>
<td>6</td>
</tr>
<tr>
<td>14) I can assess the performance of my peers adequately</td>
<td>5</td>
</tr>
<tr>
<td>15) I can evaluate new information and reassess my knowledge</td>
<td>6</td>
</tr>
</tbody>
</table>

Students were asked to rate their disagreement/agreement to a series of statements on a 7-point scale, from 1 (strongly disagree) to 7 (strongly agree).
TABLE 4. Student evaluations of tutors

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Knowledge of the program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) The tutor had sufficient knowledge of problem based learning</td>
<td>6</td>
<td>5-7</td>
</tr>
<tr>
<td>b) The tutor understood and familiarized the students with the roles of tutor and student in self-directed small-group learning</td>
<td>6</td>
<td>4-7</td>
</tr>
<tr>
<td>2) Skills displayed in tutoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Facilitative teaching: the tutor asked stimulating questions that challenged students appropriately</td>
<td>6</td>
<td>5-7</td>
</tr>
<tr>
<td>b) The tutor promoted problem solving and critical thinking, which was conducive to examining issues and synthesizing information</td>
<td>6</td>
<td>5-7</td>
</tr>
<tr>
<td>c) The tutor was constructive in setting objectives and in tutorial functioning in general</td>
<td>6</td>
<td>4-7</td>
</tr>
<tr>
<td>d) The tutor assisted students in trying to obtain the best possible personal learning agenda</td>
<td>6</td>
<td>3-7</td>
</tr>
<tr>
<td>e) The tutor reviewed learning achievements and provided feedback</td>
<td>6</td>
<td>4-7</td>
</tr>
<tr>
<td>3) Personal characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) The tutor appeared to enjoy tutoring and made a stimulating learning environment</td>
<td>6</td>
<td>5-7</td>
</tr>
<tr>
<td>b) The tutor was responsible and available</td>
<td>6</td>
<td>4-7</td>
</tr>
</tbody>
</table>

Students were asked to evaluate the tutor on a 7-point scale, from 1 (strongly disagree) to 7 (strongly agree).

The tutors. The tutors are the second major element that can make or break a tutorial process. Some of the elements that may be important can be gauged from the questionnaire distributed to the students at the end of the pharmacology course. These include knowledge, skills, and personal characteristics (Table 4). The role of the tutor is not an easy one; it is important to emphasize that tutors should be experts in tutoring first and experts in their chosen specialty next. This poses serious problems for departments wishing to institute this form of learning. Faculty are often recruited on the basis of commercial criteria, such as papers published and dollars brought in. The very qualities that make the successful grantee a capacity for salesmanship, may make voluntary self-effacement difficult. Being a tutor requires intense personal contact, which is contrary to the delegate-and-depart style favored by most manager-scientists. The tutorial process could appear extremely inefficient, since the pleasures of learning for oneself cannot be readily quantified, and busy faculty members may be sorely tempted to step in and deliver minilectures. This quickly destroys the process of learning. It is vital to have the right tutors, since students who come from more traditional backgrounds may find it difficult to challenge authority. As students get more comfortable with the process, they may choose to ignore the tutor, who may then feel threatened. The tutor must be available to the students and be able to provide them with ongoing formative evaluation. A few faculty members, acting as “organizational rascals” can become instruments of change in introducing problem-based learning, provided they have been appropriately trained and sufficiently motivated (21).
TABLE 5. Problems for studying gastric acid secretion

<table>
<thead>
<tr>
<th>Problem</th>
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</table>
| Dr. S. R. has been studying the mechanisms underlying gastric mucosal damage using a variety of experimental models. The production of duodenal ulcers by the constant infusion of histamine in the multimammate mouse [Praomys (Mastomys) natalensis] has proved particularly useful for her studies. When she acquires a new graduate student, M. N., she suggests that he explore the possible effects of thyroidectomy on the production of duodenal ulcers and refers him to a report published in Am. J. Physiol. 256 (Gastrointest. Liver Physiol. 19): G975–G978, 1989. M. N. learns that thyroidectomy decreases parietal cell numbers and basal acid secretion in rats. The responses to histamine are also reduced. The chronic administration of thyroxine has the converse effects. Further literature searches lead him to articles showing that the microinjection of thyrotropin-releasing hormone (TRH) and similar analogues into the dorsal vagal complex in rats increases gastric acid secretion. He is puzzled as to how these observations tie in with the effects of thyroidectomy.

Student-Generated Learning Objectives

1) Experimental models of ulcers
2) Anatomy/function of structures involved in gastric acid secretion (parietal cells, etc.)
3) Effects of histamine on gastric secretion
4) Effects of thyroidectomy/thyroxine on gastric secretion
5) TRH, its relations to thyroid, role of dorsal vagal complex

Faculty-Generated Objectives

1) Mechanisms of ulcer formation
2) Models for studying gastric mucosal damage
3) Histamine and ulcer formation
4) Histamine and gastric acid secretion
5) Parietal cell physiology
6) Parietal cell numbers and thyroid states
7) Thyroid hormones
8) Central control of gastric acid secretion
9) Vagal effects on gastric secretion

Problem 2

Shift workers at Huron Steel have been found to consult occupational health services for gastrointestinal (GI) complaints more frequently than do day workers. Studies have found that such disorders were more frequently observed in the young and unmarried shift workers as well as those who smoked heavily. Peptic ulcers were diagnosed in 9.8% of shift workers but only in 5.8% of day workers. Further peptic symptoms without demonstrable ulcers were found in 5.1% of shift workers but in only 3.0% of day workers.

The Divisional Head of Gastroenterology at Huronsville Medical Center is approached for help. He offers to undertake an experimental study since the GI Investigational Unit is well equipped for 24-h continuous monitoring studies. A protocol is prepared to investigate gastric acid output and pepsin in gastric juices as well as measurements of serum melatonin and cortisol concentrations.

Prof. R. M. has been studying gastrointestinal damage in various experimental models. She has noted that damage produced by acidified mucosal aspirin varies considerably with phases of the light/dark cycle in rats. She is asked whether she would be interested in submitting a research proposal for possible funding by Huron Steel. She invites her graduate students to participate in a "brainstorming" session.

Student-Generated Learning Objectives

1) Peptic ulcers: incidence in different populations
2) Experimental methods for studying GI function in humans and GI damage in animals
3) Factors affecting gastric acid secretion
4) Light/dark cycles in rats: how do these apply to humans?
5) Why were serum cortisol and melatonin measured?

Faculty-Generated Objectives

1) Peptic ulcers: underlying pathophysiology
2) Circadian rhythms: specific relation to gastric secretion
3) Methods for studying gastric function in humans
4) Factors modulating gastric secretion
5) Experimental models of gastric mucosal damage

shown in Table 5. Given below each problem is a list of faculty-generated objectives. The problems were field tested using a single group of six students who were asked to generate learning objectives. These are listed as well. The students did glean from the problems the major issues that were identified, although they used different terms. Clearly there are redundancies. It was interesting to note that the students unanimously preferred problem 2, which they felt was better organized and served to link human and animal physiology.

The use of extracts from journals is particularly exciting for undergraduate students, since they often see scientific concepts in textbooks expressed in terms of finality. The notion that science in the making can be tentative, confusing, and exciting is a revelation. Myriad of journals are available to select suitable examples. Traces from experiments, schematic diagrams, and graphical display of data can be useful starting points. Hypothetical scenarios or actual clinical cases can also be used as sources for problems. "Life," as Malvin (10) recently commented, "is filled with wonderful examples of physiological concepts at work." Many can be starting points for a problem-based course.

Other elements. Although the three cardinal elements are described above, other elements that ease the process include material resources, such as libraries and ready access to photocopiers. These elements are taken for granted in the affluent countries but pose serious problems elsewhere. If students are to be genuinely empowered with their own learning, it is important to provide them with the necessary infrastructure. It is also essential to emphasize that this kind of program can be best assessed by process-oriented examinations. Students trained in such programs may not do spectacularly in conventional exercises such as multiple-choice questions. No track authority will decide the future prospects of a marathoner on a sprint, but such fallacious approaches abound in the academic world. It is important for those...
wishing to institute such programs to have the courage of their convictions in refusing to comply with assessments that may have bureaucratic convenience but little relevance for the program at hand. Interestingly, Wen-Wei (24) reported recently that students who undertook self-directed learning fared as well or better than a control group on the same examinations. Ongoing formative evaluation is critical for the success of such ventures. Unfortunately, this is difficult to do in practice; students are hesitant to evaluate each other and feel threatened by honest evaluations from the tutors. However, such problems can be resolved with time and practice.

It must be emphasized again that self-directed problem-based learning is not a panacea; the road to successful problem-based approaches is not easy and should never be taken without much thought and preparation. However, the results could be worthwhile. It is certainly exhilarating for both student and staff to see learning as becoming rather than having become.

I owe a particular debt of gratitude to the enthusiastic eager students who enrolled in this experimental course. I would also like to thank Drs. J. Huizinga, S. MacLeod, M. Richardson, J. Rosenfeld, and G. Singh, who were the other tutors, for their active participation. Barbara McGlinchey carefully typed the manuscript.

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REFERENCES