This chapter reviews the motivation for the change to problem-based learning, its definition, and the educational objectives it can serve. It discusses changing an established curriculum to problem-based learning and asks whether problem-based learning is worth the trouble.

Problem-Based Learning in Medicine and Beyond: A Brief Overview

Howard S. Barrows

Designing a new curriculum, developing new teaching tools, training faculty to develop new teaching skills, and nurturing students through a fundamental change in learning is an expensive and time-consuming effort. Twenty-five years ago, a newly created medical school went to this trouble, and in the ensuing years, many others have followed suit.

A brief review of the factors that motivated the need for curricular change will serve as an introduction to problem-based learning (PBL). The McMaster University Faculty of Health Sciences established a new medical school with an innovative educational approach to be used throughout its entire three-year curriculum, an approach now known the world around as problem-based learning. It graduated its first class in 1972. At about the same time, the College of Human Medicine at Michigan State University implemented a problem-solving course as a separate track in its preclinical curriculum (Jones and others, 1984). Stimulated by the McMaster approach, and with cross-fertilization, other newly created medical schools in Maastricht (the Netherlands) and in Newcastle (Australia) also developed problem-based learning curricula in the early 1970s. By the early 1980s, medical schools with conventional curricula began to develop alternative, parallel problem-based curricula for a subset of their students. The leader in this trend was the Primary Care Curriculum at the University of New Mexico. Later on, other schools took on an even more arduous task of converting their entire curriculum to problem-based learning. The leader was the University of Hawaii, followed by Harvard (which had first established an alternative track) and the University of Sherbrooke in Canada.

Now there are new and established medical schools all around the globe that have developed or are developing problem-based curricula. What was the motivation behind all this effort?

In 1969, just as McMaster was getting under way, Spaulding (1969) described the motivation for creating an innovative approach: "Current dissatisfaction with medical education imposes on a new medical school a responsibility of experimenting with novel approaches" (p. 659). The McMaster group noted that students were disenchanted and bored with their medical education because they were saturated by the vast amounts of information they had to absorb, much of which was perceived to have little relevance to medical practice. They also noted that, by contrast, during residency, students were excited by working with patients and solving problems (Spaulding, 1991, p. 28).

In describing the innovative problem-based track at Michigan State, Jones and others (1984) stated that during curriculum planning it was "accepted that education in the techniques of medical problem-solving should be a part of the College's preclerkship curriculum" (pp. 181–182). My own motivation for developing a specific problem-based learning approach was similar. Studies of the clinical reasoning of students and resident physicians in neurology suggested that the conventional methods of teaching probably inhibit, if not destroy, any clinical reasoning ability (Barrows and Bennett, 1972). This, together with the observation that students had forgotten their freshman neuroanatomy by the time of their clinical neurology course as juniors, an observation reinforced by the studies of Levine and Forman (1973), led to my design of a method stressing development of the clinical reasoning or problem-solving process for the neuroscience unit of the McMaster curriculum (Barrows, 1984). This approach has been further developed in the alternative curriculum at Southern Illinois University (Barrows, 1994).

A wider dissemination of problem-based learning in the United States resulted from the *Report of the Panel on the General Professional Education of the Physician and College Preparation for Medicine,* known as the "GPEP report" (Muller, 1984) sponsored by the Association of American Medical Colleges. This report made many recommendations for changes in medical education, such as promoting independent learning and problem solving, reducing lecture hours, reducing scheduled time, and evaluating the ability to learn independently. These were perceived as support for problem-based learning by many medical school deans and faculty who were, as a consequence of this report, initiating curricular reviews.

Now countless medical schools in the United States have developed or are developing problem-based curricula in courses, alternative curricula, or as an entire curriculum revision. Many schools, particularly those with long traditions, want to create their own variation of problem-based learning that reflects their rigor and excellence. This often includes blending problem-based learning with elements of their conventional teaching into a hybrid, as a compromise with faculty unconvinced about the value of problem-based learn-

ing. All these approaches to problem-based learning represent such a wide variety of methods that now the term has far less precision than might be assumed (Barrows, 1986).

The Definition of Problem-Based Learning

In spite of the many variations of PBL that have evolved during its dissemination as a new method in medical education, a core model or basic definition with which others can be compared is needed. The original method developed at McMaster works well as this model. Its characteristics are these.

Learning Is Student-Centered. Under the guidance of a tutor (as described later in this chapter), the students must take responsibility for their own learning, identifying what they need to know to better understand and manage the problem on which they are working and determining where they will get that information (books, journals, faculty, on-line information resources, and so forth). "Resource faculty" in many different subject areas are available to the students as consultants. This allows each student to personalize learning so as to concentrate on areas of limited knowledge or understanding, and to pursue areas of interest.

Learning Occurs in Small Student Groups. In most of the early PBL medical schools, groups were made up of five to eight or nine students. Characteristically, at the end of each curricular unit, the students are resorted randomly into new groups with a new tutor. This gives them practice in working intensely and effectively with a variety of different people.

Teachers Are Facilitators or Guides. At McMaster the group facilitator was referred to as a *tutor.* This role was often defined in negative terms. It was someone who did not give students a lecture or factual information, did not tell the students whether they were right or wrong in their thinking, and did not tell them what they ought to study or read. The role is better understood in terms of metacognitive communication. The tutor asks students the kinds of questions that they should be asking themselves to better understand and manage the problem (Barrows, 1988). Eventually the students take on this role themselves, challenging each other. To inhibit the tutor from falling back on old teaching reflexes and giving the students direct information and guidance, McMaster promoted the concept of the "non-expert" tutor. This meant that tutors should perform in curricular units where they were not content experts. It seems generally agreed now that the best tutors are those who are expert in the area of study, only they must also be expert in the difficult role of tutor.

Problems Form the Organizing Focus and Stimulus for Learning. In PBL for medicine, a patient problem or a community health problem is presented in some format, such as a written case, case vignette, standardized (also called *simulated)* patient, computer simulation, videotape. It represents the challenge students will face in practice and provides the relevance and motivation for learning. In attempting to understand the problem, students realize

what they will need to learn from the basic sciences. The problem thus gives them a focus for integrating information from many disciplines. The new information is also associated with cues patient problems present. All this facilitates later recall and application to future patient problems.

Problems Are a Vehicle for the Development of Clinical Problem-Solving Skills. For this to happen, the problem format has to present the patient problem in the same way that it occurs in the real world, with only the patient's presenting complaints or symptoms. The format should also permit the students to ask the patient questions, carry out physical examinations, and order laboratory tests, all in any sequence. The students should get the results of these inquiries as they work their way through the problem. Such formats as the "P4" (Barrows and Tamblyn, 1977), the Problem-Based Learning Module (Distlehorst and Barrows, 1982), standardized patients (Barrows, 1987), and computer simulations can allow for free inquiry as in clinical practice.

New Information Is Acquired Through Self-Directed Learning. As a corollary to the characteristics already described (the student-centered curriculum and the teacher as facilitator of learning), the students are expected to learn from the world's knowledge and accumulated expertise by virtue of their own study and research, just as real practitioners do. During this self-directed learning, students work together, discussing, comparing, reviewing, and debating what they have learned.

Educational Objectives Possible with a Problem-Based Curriculum

These were the original characteristics for problem-based learning before its dissemination in medicine and elsewhere. This model makes the educational objectives listed in this section possible. Each objective is followed by a description of curricular design elements needed to address the objective.

The Acquisition of an Integrated Knowledge Base. For this to happen, all medical school disciplines basic to medical practice need to be incorporated into the problem-based learning curriculum. In a number of schools, some disciplines are taught outside the problem-based learning curriculum. Not only does this inhibit integration of those subjects in the students' understanding of a patient's problem, it also requires students to move in and out of different learning approaches, passive versus active, dependent versus independent. Many disciplines beyond the usual basic sciences, such as behavior, humanities, community health, ethics, epidemiology, need to be incorporated into the curriculum.

The Acquisition of a Knowledge Base Structured Around the Cues Presented by Patient Problems. By organizing their knowledge around patient cues, medical students enhance their ability to recall what they have learned and apply it in clinical work. This objective could be accomplished by any problem-based learning curriculum in which students analyze and resolve

the problem as far as possible before acquiring any information needed for better understanding. This objective may represent the absolutely irreducible core of problem-based learning, if such a thing were to be articulated.

The Acquisition of a Knowledge Base Enmeshed with Problem-Solving Processes Used in Clinical Medicine. The Development of an Effective and Efficient Clinical Problem-Solving Process. These two objectives cannot be realized unless patient problems are presented in a format that allows students to use the problem-solving skills needed in practice. For example, the problem-based curriculum at Southern Illinois University stresses the use of patient formats such as the PBLM (Distlehorst and Barrows, 1982) and standardized patients to allow students to inquire freely of the patient. By contrast, the problem-based curriculum at Maastricht presents students with patient problem protocols that contain most of the information needed to analyze and resolve the problem. The faculty feel it is inappropriate for undergraduate students to be in the vocational context of being a physician while they are in the academic pursuit of knowledge basic to medicine. These cognitive skills would be developed in their later clinical work (W. H. Gijselaers, personal communication, 1994). Other schools use formats that only develop some skills in problem solving (Barrows, 1990). This point is not appreciated by those making the observation that problem-based learning students do not seem to have better problem-solving skills when compared to students in conventional curricula (Barrows, 1996). In many problem-based learning curricula, the development of these skills is not addressed.

The Development of Effective Self-Directed Learning Skills. The Development of Team Skills. These goals require that the PBL approach be student-centered. Students must be able to determine on their own what to learn and from what resources, guided by the facilitator or tutor. This educational goal is easily weakened by tutors who are directive with students, by faculty statements about learning expectations with each problem, by reading assignments paired with problems, by resource faculty who tell the students what they should know as opposed to answering their questions, and by faculty-generated multiple choice questions to assess student progress. All these tend to make the students dependent on the faculty telling them what to learn, as in conventional curricula, instead of being the independent learners that they must be in medical practice.

There are other educational goals that could be added. There are also many other variables that can confound these goals, such as the expected role of the tutor, the tutor training employed, the size of the student group, and the existence of competing curricular activities outside of PBL.

If effort, money, and time are to be invested in developing a PBL curriculum, it would seem worthwhile to achieve all the possible advantages of the method. Compromises are often made by schools or teachers unaware of all that PBL can accomplish and of the damage that apparently easy or trivial compromises in curricular design can do to this potential.

Changing an Established Curriculum to Problem-Based Learning

Most medical schools that have changed to problem-based learning share several characteristics. The dean either encourages PBL or provides visible support to a faculty group that wants to change to PBL. There is also a group of internally credible faculty members from both the clinical and basic sciences who want to change to PBL and are willing to spend the time and effort necessary.

Other factors that contribute to curricular change are visits by both enthusiastic and skeptical faculty members to schools using PBL and a demonstration of PBL at the school, using the school's own students. It also helps to have interested faculty members go through a PBL experience themselves to appreciate the motivation and desire to learn that is produced despite their already established expertise in medicine. Presentations and lectures about problem-based learning are unconvincing—the listeners conjure up their own ideas as to what the method is like based on their own past experiences. Demonstration and experience make all the difference. If problem-based learning is to be tried, it should be given the opportunity to flourish.

The Curriculum in Problem-Based Learning

The previously stated goals for PBL describe skills that can be developed with this method—problem-solving, self-directed learning, and team or collaborative learning skills. They also suggest that the nature of learning is active, integrated, and associated with the cues present in real-world professional problems (patients) and the cognitive processes used in problem solving. They do not circumscribe the subject matter of the curriculum. An outsider cannot review these goals and determine what the students will learn in a problem-based curriculum. In fact, as the method is student-centered and self-directed, an outsider might mistakenly assume that PBL is chaos or a free educational happening with students learning whatever they wish. The curricular linchpin in PBL—the thing that holds it together and keeps it on track—is the collection of problems in any given course or curriculum with each problem designed to stimulate student learning in areas relevant to the curriculum.

In some PBL curricula, the areas of expected learning with each problem (so-called learning objectives) are written down. This list is not made available to the students until after they have carried out all the self-directed learning they feel is needed and have finished their work with the problem. The list serves as a guide to faculty tutors not expert in the subject under study. It helps them guide students into areas of discussion that lead to productive learning. The objectives can also be assembled into a matrix with the problem titles across the top and the expected content objectives for the course listed down the side. Under each problem title, the subject matter addressed (in the mind of the course director) is checked off. There usually is redundancy as several

problems may address similar areas of content, but that is all to the good. This matrix allows course directors and anyone else interested to see the putative course content. A major advantage of PBL is that the students, responsible for their own learning and engaged in self-directed learning and stimulated by the problem, may pursue areas of study far beyond the fondest dreams of the course designer.

The matrix is also a valuable device for designing a PBL curriculum because it allows faculty members to translate what they have been teaching in their conventional curricula to PBL. They list all the important (not trivial) subject matter areas taught in each course down the left side. As patient problems are identified and added to the top of the matrix, the specific subject areas addressed are checked off. As the process continues, it is often seen that some content areas are not being addressed and particular effort will have to be taken to find a patient involving those areas. If a patient problem cannot be found, the relevance of that content area for medical student learning can be questioned.

This is a very logical way to choose problems for a PBL curriculum in medicine. For example, in a medical unit on cardiovascular and renal organ systems, the faculty determines the patient problems that will most likely be encountered by the students in their clinical courses, residencies, and in practice and includes these in the unit. This list of prevalent or common problems is augmented by cardiovascular or renal patient problems which, although not frequent, represent significant morbidity or mortality (and consequent financial burden to the health care system) if not recognized and properly managed. Then, whatever the students need to learn in the related basic sciences to evaluate, analyze, and manage these problems is the relevant content for self-directed study. An additional value to this curricular planning approach is that the curriculum is easily updated and kept relevant by adding new problems that surface in medicine. A similar strategy for developing a PBL curriculum could be applied in any technical or professional field.

Is Problem-Based Learning Worth the Trouble?

Interestingly, this question is usually raised by people who are asked to consider the possibility of a problem-based curriculum without having ever been involved in, or observing, problem-based learning. Once anyone is involved as a PBL tutor and has the opportunity of seeing what students can do when given the permission to think and learn on their own, he or she usually becomes a convert. Faculty members can see how students think, what they know, and how they are learning. This allows teachers to intervene early with students having trouble before it becomes a more difficult issue. Faculty members work with alert, motivated, turned-on minds in a collegial manner that has no equal. This is quite different from lecturing to a passive and often bored array of students whose understanding of the subject the teacher can only deduce indirectly from their answers to test questions.

The irony is that few formal assessment procedures can distinguish problem-based learning students from conventional curriculum students because such procedures are generally insensitive to the cognitive and behavioral differences that are observed in PBL. Yet faculty members who work with both conventional curriculum students and PBL students observe that there is a marked difference. There are two meta-evaluations that have pooled the results of many PBL evaluations performed over the last twenty years (Albanese and Mitchell, 1993; Vernon and Blake, 1993). These studies indicate that PBL has done no harm in terms of conventional tests of knowledge and that students may show better clinical problem-solving skills. They also show that students are stimulated and motivated by PBL as a method.

The proof is in the pudding. Teachers have to see problem-based learning in action, talk to students, and—most important—try it themselves. If they do this, concerns for evaluation diminish as they realize that PBL is a natural way for future doctors to learn.

Problem-Based Learning Outside the Medical Domain

Over the last two decades, PBL approaches and curricula have been developed in many other areas of education in professional schools (nursing, law, engineering), college-level courses, and kindergarten through 12th grade. Woods (1994) has developed PBL approaches in engineering at McMaster University for almost as many years as the medical school has existed. Stinson has developed an MBA program that is totally problem-based and introduced PBL into the final year of an undergraduate curriculum in business administration at Ohio University (Milter and Stinson, 1995). Gijselaers (1995) has developed a PBL curriculum in business at Maastricht. Boud and Felleti (1991) provide an excellent overview of the application of problem-based learning to many different disciplines.

More recently, Kelson and I have been working with high school teachers, initially in science, applying PBL to high school education. The Problem-Based Learning Institute, a cooperative venture between School District 186 in Springfield and Southern Illinois University School of Medicine, has developed problems and teacher-training programs in PBL for all the core disciplines in high school (Barrows and Kelson, 1993). The immediate interest in PBL shown by teachers after seeing it demonstrated, and the excitement shown by students and teachers who become involved, caused rapid dissemination. The method is perceived as the solution to many problems in education, such as the current tendency to produce students who cannot think or solve problems and who are bored with education.

As Internet list servers that support exchanges between those involved in problem-based learning reveal, there are many teachers using problem-based learning in many disciplines and professions and at many different educational levels around the world, and the numbers will grow as teachers see what PBL can accomplish.

References

Albanese, M. A., and Mitchell, S. "Problem-Based Learning: A Review of Literature on Its Outcomes and Implementation Issues." *Academic Medicine,* 1993, *68* (1), 52–81.

Barrows, H. S. "A Specific, Problem-Based, Self-Directed Learning Method Designed to Teach Medical Problem-Solving Skills, Self-Learning Skills and Enhance Knowledge Retention and Recall." In H. G. Schmidt and M. L. DeVolder (eds.), *Tutorials in Problem-Based Learning.* Assen/Maastricht, the Netherlands: Van Gorcum, 1984.

Barrows, H. S. "A Taxonomy of Problem-Based Learning Methods." *Medical Education,* 1986, *20,* 481–486.

Barrows, H. S. *Simulated (Standardized) Patients and Other Human Simulations.* Chapel Hill, N.C.: Health Sciences Consortium, 1987.

Barrows, H. S. *The Tutorial Process.* Springfield: Southern Illinois University School of Medicine, 1988.

Barrows, H. S. "Inquiry: The Pedagogical Importance of a Skill Central to Clinical Practice." *Medical Education,* 1990, *24,* 3–5.

Barrows, H. S. *Practice-Based Learning: Problem-Based Learning Applied to Medical Education.* Springfield: Southern Illinois University School of Medicine, 1994.

Barrows, H. S. "Problem-Based Learning and Problem Solving." *PROBE Newsletter of the Australian Problem-Based Learning Network,* 1996, *26,* 8–9.

Barrows, H. S., and Bennett, K. "The Diagnostic (Problem-Solving) Skill of the Neurologist." *Archives of Neurology,* 1972, *26,* 273–277.

Barrows, H. S., and Kelson, A. *Problem-Based Learning in Secondary Education and the Problem-Based Learning Institute* (Monograph). Springfield: Southern Illinois University School of Medicine, 1993.

Barrows, H. S., and Tamblyn, R. M. "The Portable Patient Problem Pack: A Problem-Based Learning Unit." *Journal of Medical Education,* 1977, *52* (12), 1002–1004.

Boud, D. J., and Felleti, G. (eds.). *The Challenge of Problem-Based Learning.* New York: St. Martin's Press, 1991.

Distlehorst, L. H., and Barrows, H. S. "A New Tool for Problem-Based Self-Directed Learning." *Journal of Medical Education,* 1982, *57* (6), 486–488.

Gijselaers, W. H. "Perspectives on Problem-Based Learning." In W. H. Gijselaers, D. T. Tempelaar, P. K. Keizer, J. M. Blommaert, E. M. Bernard, and H. Kasper (eds.), *Educational Innovation in Economics and Business Administration: The Case of Problem-Based Learning.* Norwell, Mass.: Kluwer, 1995.

Jones, J. W., Bieber, L. L., Echt, R., Scheifley, V., and Ways, P. O. "A Problem-Based Curriculum—Ten Years of Experience." In H. G. Schmidt and M. L. DeVolder (eds.), *Tutorials in Problem-Based Learning.* Assen/Maastricht, the Netherlands: Van Gorcum, 1984.

Levine, H. G., and Forman, P. B. "A Study of Retention of Knowledge of Neurosciences Information." *Journal of Medical Education,* 1973, *48* (9), 867–869.

Milter, R. G., and Stinson, J. E. "Educating Leaders for the New Competitive Environment." In W. H. Gijselaers, D. T. Tempelaar, P. K. Keizer, J. M. Blommaert, E. M. Bernard, and H. Kasper (eds.), *Educational Innovation in Economics and Business Administration: The Case of Problem-Based Learning.* Norwell, Mass.: Kluwer, 1995.

Muller, S. (Chair). "Physicians for the Twenty-First Century: Report of the Project Panel on the General Professional Education of the Physician and College Preparation for Medicine." *Journal of Medical Education,* 1984, *59* (11, Part 2).

Spaulding, W. B. "The Undergraduate Medical Curriculum (1969 Model): McMaster University." *Canadian Medical Association Journal,* 1969, *100,* 659–664.

Spaulding, W. B. "Revitalizing Medical Education." *McMaster Medical School in the Early Years, 1965–1974.* Philadelphia: Decker, 1991.

Vernon, D.T.A., and Blake, R. L. "Does Problem-Based Learning Work? A Meta-Analysis of Evaluative Research." *Academic Medicine,* 1993, *68* (7), 550–563.

Woods, D. R. *Problem-Based Learning: How to Gain the Most from PBL.* Waterdown: D. R. Woods, 1994. (Distributed by McMaster University Bookstore, Hamilton, Ontario, Canada.)

HOWARD S. BARROWS is professor and chair, department of medical education, Southern Illinois University School of Medicine, Springfield, Illinois.