Southern Illinois University School of Medicine
Department of Medical Education MC 9622
P. O. Box 19622
Springfield, IL 62794-9622
(217) 782-0795
FAX: (217) 524-0192

Problem-Based Learning:

A Total Approach to Education

Howard S. Barrows, M.D.
and
Ann Myers Kelson, M.A.

INTRODUCTION

PBL is a total approach to education. In PBL there is a curriculum of carefully selected and designed problems. And there is a PBL process, which, among other things, replicates the commonly used systematic approach to resolving problems or meeting challenges. Student and teacher roles are redefined. Students assume the responsibility for learning and teachers become facilitators: stimulating and guiding students' in their problem solving and self-directed learning.

THE NEED

All levels of education today B primary, secondary and university are inundated with complaints about the status of education and advice as to how it should be changed. Students are passive; they score poorly on national examinations; they know little of the world around them, and they seem not to care; they appear to have little interest in their future or that of their community or nation. The complaints can be summarized as follows: Students do not learn enough, what they learn they do not retain; what they retain they cannot use flexibly. Students do not use higher order thinking skills; they tend to think literally and to focus on memorization as their primary mode of information processing. Students are highly dependent; they expect to be told precisely what they are to learn and what they will be tested on. Attempts to make academics relevant fail. Students are not only passive; they are poorly motivated and disinterested in education. Faculty are frustrated by the fact that their efforts to improve teaching are compromised by the demands of behavior management in the classroom.

Unfortunately, the usual response to these concerns is piecemeal. To address the knowledge problem, new courses are created, more information is added to traditional courses, examinations are made more rigorous and entrance requirements are increased. To address the problems of low level thinking, lack of motivation and behavior problems, faculty are encouraged to try new thinking exercises, new educational techniques, new strategies as add-ons to their conventional teaching. Adding more content does not adequately address the problem of knowledge retention, and the application of algorithmic thinking strategies isolated from course content does not adequately address the inability to reason and lack of motivation. In fact, as most teachers recognize, these Abandied@ solutions only intensify the problems. Because students are already inundated in every course with information they have to memorize to pass examinations, adding content does not help. Algorithmic techniques have yet to show transfer beyond the exercises designed to develop the techniques and many motivational strategies merely elevate the student's expectation to be entertained.

Educators across the country are beginning to realize that the **pervasiveness and intensity of these problems demands that the entire approach to education be re-evaluated.**

We may begin to address the issue by looking at the ambiguity in the word Alearn.@ There has been a great concentration on **what** the student learns with little, if any, regard to **how** the student learns. Yet, research in cognitive science strongly suggests that **what** is learned (and particularly the usability of what is learned) is inextricably intertwined with how it is learned. When learning is considered merely as acquisition of information, then the learning process demanded is rote memorization. What is learned is encapsulated to meet the expected demands of the test. When problem solving is approached, as the ability to identify solutions of closed-ended problems in which there is one right answer, then the problem solving demanded of students is the ability to follow well-defined rules or routines. What is learned is a set of algorithms and their expected outcomes. When learning and problem solving in school involves artificial tasks that would never occur in the real world outside of school, then what is learned is considered irrelevant by the student and encapsulated in the Aschool knowledge@ compartment of the student's mind. When information, rules and routines are delivered intact by the teacher, then the student comes to believe that learning is a largely passive exercise, and that knowledge lies in the hands of someone other than the student. When collaborative effort is labeled as Acheating@, then students view the learning process as constrained by their own limitations.

THE MULTIPLE DIMENSIONS OF THE PBL PROCESS

The PBL process is an ordered instructional approach that models the process by which experts systematically approach real-life problems. Before beginning this description, it is well to review certain characteristics of PBL problems and their congruence with characteristics of real-world problems. PBL problems, like all challenging real-world problems, are messy and ill-structured. There is no single right answer. They lead the problem-solver to generate multiple hypotheses from their initial presentation. They require the problem-solver to inquire for more information in order to refine these hypotheses and move toward a resolution. This process of generating hypotheses, inquiring for more information and refining hypotheses, sometimes called **hypothetico-deductive reasoning or Athe scientific method,@ is the first dimension incorporated into the PBL process.**

PBL problems are selected and intentionally designed so that students will recognize that they are unable to resolve the problem or meet the challenge with their present level of knowledge and skills. In the course of working through a problem students recognize that in order to continue to work effectively they must gain more knowledge and skills. A curriculum of PBL problems is developed so that as a set the problems seduce students into acquiring a domain of knowledge and skills.

The use of the word Aseduce@ is deliberate. Students are not informed beforehand of the objectives for which the problems were designed. The facilitator does not direct the students toward these objectives. It is the **problem** that stimulates the need to know; students are internally driven to develop the desired knowledge and skills because these are essential for arriving at the best possible resolution for the problem. The PBL process capitalizes on the need to know that is stimulated by a problem.

The **need** for knowledge and skills becomes the goal for learning. Knowledge and skills are not acquired in a compartmentalized fashion and held intact in order to pass a test. Knowledge and skills are **developed.** The need to know generated by the problem drives the learner not just to acquire information from pre-identified sources, but to dig out on his own from several sources and disciplines, to dissemble, to reassemble, to re-shape, to recall and readjust previously acquired concepts and skills; in short to work over what she finds so that it makes sense for the present context. Over time learning activity in a problem-based curriculum leads to a richly elaborated and integrated base of knowledge and skills. Equally important, it leads to the development of the capacity and habit of mind which integrates knowledge seeking, recall and shaping, a capacity called cognitive flexibility. **Developing cognitive flexibility and a richly elaborated base of integrated knowledge and skills is a second dimension of the PBL process.**

Although the PBL problem is designed to stimulate the need to know, the PBL process keeps this need alive. As students work through the problem guided by the facilitator, they are continuously made aware of the need to know more in order to arrive at an optimal resolution. Just prior to and immediately following self-directed learning periods, the PBL process focuses students on planning for and critically reviewing sources that will serve as efficient and effective means for acquiring the necessary knowledge and skills. Recognizing what knowledge and skills are needed, knowing what resources should be used, learning how to acquire them in an efficient, effective manner, and learning to shape this newly acquired knowledge so that it contributes to the problem solution are all part of the skills, and the mindset, that make for life-long learners. **Developing life-long self-directed learning skills is a third dimension that is incorporated into the PBL process.**

The fourth dimension of the PBL process fosters the development of collaboration skills. Most significant problems in real life can only be resolved satisfactorily through the collaborative efforts of a number of people approaching the problem from multiple perspectives and offering a repertoire of perceptions, knowledge, skills and wisdom. Most of what we do in school is the antithesis of this kind of collaborative effort. ADo your own work@ is a common school warning not

to cheat. The PBL Process is designed to encourage development of the skills necessary to work and learn effectively as members of a collaborative team working toward a common goal without sacrificing the development of the individual as a competent, confident, independent contributor to society.

The fifth dimension of the PBL process over-arches all the others. PBL is studentcentered. Its goal is to produce students who take responsibility for the improvement of themselves and their community, students who meet problem challenges with initiative and enthusiasm, and who have the knowledge, skills and self-direction to continue developing across the life span. This means that the default for every decision is: AIt's the students' responsibility.@ What needs to be learned? It is the students' responsibility to decide. What resources should be used? How do we manage time and resources? Students' participate in the decision. How do we manage a problem with group dynamics or behavior? The challenge is given to the students. Faculty input into student decision-making is at the level of curriculum development: problem selection and design. When the problem is being developed, it belongs to the faculty. Once it is given to the students, it is theirs.

The sixth dimension of the PBL process is the development of self-reflection and selfappraisal habits that are necessary for honest self-assessment and setting of realistic goals. Throughout the PBL process the PBL facilitator verbalizes models for self-questioning that students can internalize. The facilitator asks AWhy?@ strategically so that students will begin to be able to assess the accuracy and depth of their knowledge. The tutor asks about the quality and accessibility of resources so that students will begin to develop critical appraisal skills. The tutor consistently asks that students cite evidence for their verbal self-evaluation at the end of each problem so that students will begin to internalize the habit of reviewing and reflecting on their performance. And as a part of this self-evaluation process the tutor asks students to identify goals for the next problem and strategies for reaching them. As a consequence students develop the capacity and mindset which combine self-reflection and appraisal with goal setting and planning.

These six dimensions B problem-solving, develop a functional knowledge base and cognitive flexibility, self-directed learning, collaboration, taking on the responsibility for these challenges with initiative and enthusiasm, and developing the capacity and mindset for reflection and selfappraisal - are integrated into a fluid process which forms a scaffold for the PBL teacher acting as facilitator. Since PBL problems simulate the challenges of the real world, outside of the classroom, and the PBL process encourages behaviors that should be used to tackle these challenges, learning in PBL is seen by students as relevant and exciting. No effort is wasted on learning activities of limited value in the real world such as rote memorization of information provided in lectures and reading assignments. For these reasons PBL provides what educators refer to as Aauthentic@ learning.

Problem-Based Learning is a complete and comprehensive approach to education designed to replace traditional, didactic, teacher-centered approaches. It encompasses within its structure and process the intent of many popular educational activities such as collaborative learning, the development of critical thinking (problem solving skills) or independent learning skills and gives them context and meaning.

EDUCATIONAL OBJECTIVES OF PBL

The shape of the PBL process is determined by these educational objectives that reflect its six dimensions:

Students will:

1) Develop a systematic approach to solving real-life problems, using higher order thinking skills (problem-solving, critical thinking, decision-making).
2) Acquire an extensive, integrated knowledge base that can be recalled and flexibly applied to other situations.

3) Develop effective self-directed learning skills, identifying what they need to learn, locating and using appropriate resources, applying the information back to the problem, and reflecting on, evaluating, and adjusting their approach for greater efficiency and effectiveness.
4) Develop the attitudes and skills necessary for effective team work with others working on a task or problem.
5) Acquire the life long habit of approaching a problem with initiative and diligence and a drive to acquire the knowledge and skills needed for an effective resolution.
6) Develop habits of self-reflection and self-evaluation that allow for honest appraisal of strengths and weaknesses and the setting of realistic goals.

OVERVIEW OF THE PROBLEM-BASED LEARNING (PBL) PROCESS

In the PBL Process, students work through a series of problems designed to be authentic (i.e. address real-world concerns) and to target defined areas of the curriculum. The problems are messy and ill-structured. Since they present with only a minimal amount of information and there are a number of possible explanations and solutions, PBL Problems must be defined and analyzed through inquiry. The problem presentation approximates the real world as nearly as possible so that students find themselves actually engaged in the problem and not just observers of it or role playing with it. Students are coached through the process by a teacher who is trained to facilitate their reasoning through the problem.

As students work through the problem, they are frequently divided into small working groups within the classroom. The teacher specifically trained in PBL facilitation skills, guides them through the hypothetico-deductive reasoning process with each problem. Data are gathered, hypotheses generated and tested, and conclusions drawn, in this time-honored method of reasoning scientifically. Throughout the process, as students define and analyze the problem, they generate Alearning issues.@ These are areas of knowledge in which they feel they are not sufficiently prepared to fully and correctly understand the problem under study. The deliberations of the group are organized and continuously recorded by a member of the group on a chalkboard. The chalkboard is sectioned to record hypotheses generated and their justification (AIdeas@), emerging information about the problem (AInformation@), matters for further study (ALearning Issues@) and developing plans for resolving or improving the problem situation (AActions@).

Ideas/Hypotheses	Information	Learning Issues	Actions

In this first stage students take on the problem without prior preparation and work their way through it with the knowledge and skills they already have. This stimulates the recall, and reconstruction, of relevant concepts and skills the students already have in their heads, allowing them to realize what they already know. In this way, too, the problem activates knowledge structures that provide hooks for understanding and remembering new information they will obtain from subsequent self-directed learning.

Learning Issues define the focus of self-directed learning. When the problem has been developed to the point that further analysis and understanding is inhibited by their lack of knowledge, the students undertake self-directed learning, guided by the ALearning Issues@ and motivated by the AActions@ they anticipate taking. The design of the problem and the questioning by the facilitator will lead students to identify learning issues relevant to the curriculum content objectives.

Learning Issues guide a process called self-directed learning. Self-directed learning is **not**, strictly speaking, discovery learning, though discovery may certainly be involved. Neither is it learning in isolation. Rather it is a period when students access knowledge and skills **they** have decided they must have, using whatever resources are available. Students are encouraged to range widely and select carefully. The goal is to give free reign to the need to know, capitalizing on the energy and direction that the problem generates. Guidance of the facilitator before and after the self-directed learning time provides the scaffolding by which students range freely, yet critically, in their search for knowledge and skills that will lead to an optimal resolution of the problem.

After a period of self-directed learning, students return to the problem and begin further analysis armed with their newly acquired knowledge. In this way, the information they acquire is actively applied so that it contributes to the understanding and resolution of the problem and their prior knowledge and reasoning is verified or corrected.

At the conclusion of each problem, students are asked to articulate the knowledge they have acquired and the problem is reexamined in the context of related problems they have worked on. This encourages students to make connections across problems, to explore similarities and differences, to make generalizations. Finally, students reflect upon their efforts as problem-solvers and evaluate their own performance and that of their peers, developing reflection and self-appraisal skills essential for effective life-long learning.

Throughout this process students work collaboratively toward the problem's resolution and assume responsibility for the group's efforts in problem-solving and learning.

PERFORMANCE/PRESENTATION: ASSESSMENT AS A NATURAL OUTCOME OF PROBLEM-SOLVING

When expert problem-solvers convene a group to wrestle with a problem, it isn't just an intellectual exercise. They expect to arrive at a decision and either to carry out the action or to deliver that decision in some appropriate format to others responsible for carrying it out. There is some performance or presentation that signals that the problem-solving work is over. This is a component that is essential to the PBL processes.

Performances/Presentations can be written or oral reports, discussions, drawings, paintings, diagrams, dramatic performances, songs, musical compositions, debates, posters, videotape presentations, constructions, etc. What is possible is determined by the problem itself, but it can be structured to accommodate several purposes. The most obvious purpose is that it is the mechanism for delivering the problem resolution. It signals to the students that they have completed the problem. It serves as a goal to focus their problem-solving activities. The facilitator can also use the problem-presentation to help students stay on track by reminding them of the deadline contained within the problem for delivering the resolution. For example in a problem in which students are responding to a community or governmental agency, the actual deadlines or meeting times established for the project's presentation drives focusing of the work.

Performance/Presentation as an evaluation tool

The Performance/Presentation can also serve as an evaluation tool by incorporating a summation of what the students have learned and a building in a Ajustification@ component. Rather than merely reporting an opinion as to the most desirable resolution, the Performance/Presentation requirements dictated by the problem can require that students justify their conclusion on the basis of factual information. Problems which have students involved in community projects may be asked to present their findings before a civic group or legislative body. Requiring that the presentation include justification on the basis of existing literature, classroom research or basic science principles is reasonable and authentic for the problem, and provides a mechanism for the teacher to evaluate student understanding of the principles and concepts for which the problem was designed.

Performance/presentation can challenge multiple skills
The Performance/Presentation component provides an opportunity for taking advantage of stimulating the multiple intelligences of students. AMaking a presentation@ should not be construed as merely an oral report. Even formal reports are better if enhanced with posters, diagrams, video, slides, etc. Presentations can also include the students' creating works of art, drama, poetry, short stories, articles, and so forth. Students should be challenged not only to take advantage of their preferred modes of expression but to investigate other outlets as well.

Using external evaluation
Both the authenticity of the problem and the drive toward meticulous justification (and hence accurate and in-depth knowledge) can be enhanced if the Presentation/Performance is to be evaluated externally, especially if the external evaluator is a natural part of the problem. Arranging for students to be accountable to community or national figures not only enhances the authenticity of the problem; it provides natural incentive for excellence. Note that when such authentic delivery mechanisms are included in the problem, many Aschool type@ questions about products drop out. No one asks: ADoes neatness and spelling count.@ They just do! No one asks AHow many pages.@ The real-life constraints of regulations or practicality dictate the length.

THE TEACHER'S ROLE

The PBL process is Astudent-centered@ as contrasted with Ateacher-centered.@ The students are encouraged to become responsive to challenges they encounter and are responsible for their own learning. The PBL teacher, in the facilitator role, guides rather than directs students' learning. The teacher acts as an educational tutor-facilitator throughout or coach rather than an authoritative dispenser of information.

The PBL process incorporates a natural but systematic approach to solving-real-life problems. The facilitator guides students through this systematic process. The facilitator's questioning models the kind of self-questioning students will eventually internalize to insure they are approaching problems systematically and from a sound knowledge base. The facilitator's actions to maximize group process models the actions students will internalize to make them effective members of a collaborative team. The facilitator's questioning at the self/peer evaluation time models self-questioning students can internalize for honest productive self-reflection.

The facilitatory skills of the teacher are central to the success of PBL. The teacher serves as a coach or guide for student learning. As a facilitator, the teacher challenges, questions, and stimulates the students in their thinking, problem solving and self-directed study. After a while, the students will similarly challenge each other and themselves as they work, think and learn. As students begin to take on these behaviors themselves, the facilitator can step back, allowing students to function more and more independently.

THE TEACHER AS CURRICULUM DESIGNER

One of the many exciting features of Problem-Based Learning is the empowerment of teachers to become active designers of curriculum and facilitators of learning. As curriculum designer, the typical teacher's role changes from implementing externally made curriculum decisions to being a highly involved decision-maker in the curriculum planning process

As a designer of curriculum, the teacher's challenge is to select and structure problems so that they address both the important content objectives of the curriculum and important real-world issues. This process results in a reaffirmation of the importance of some objectives, the clarification of some and the elimination of others as lacking relevance or importance.

THE TEACHER AS CONTENT RESOURCE

PBL is not discovery learning. Students are encouraged to identify and critically evaluate existing knowledge and skill resources and then to make the best possible use of them. Resources include not just print materials but computer, media and human resources as well. Because this PBL method keeps the role of facilitator separate from the role of content expert, teachers serve as content experts only to the extent of their **expertise and only when approached by students.** The trained PBL facilitator need not be a content expert; the content expert serves as resource once the students have identified the need to know. This allows faculty to work as a team, making optimal use of each individual's interests and abilities. During content resource sessions, the teacher in the role of content resource appropriately calls on the entire repertoire of techniques for helping students acquire the knowledge and skills they have identified. This includes not just explaining difficult or confusing concepts but encouraging students to use other sources for verification and working with them to shape knowledge and skills for application to the problem at hand.

SUMMARY

PBL is an ordered instructional approach that models the process by which experts systematically work through real-life problems. The process incorporates six dimensions: 1) modeling the hypothetico-deductive reasoning process or Ascientific method,@ 2) stimulating in students the need to develop a sound knowledge base from which problems can be resolved, 3) developing in students the skills for life-long learning, 4) developing in students the ability to work as members of a collaborative team, 5) developing students who take responsibility for the improvement of themselves and their community, and 6) developing students who have the propensity for honest reflection and self appraisal and who can set realistic goals.

Background of the Problem-Based Learning Method

Problem-Based Learning was introduced as a revolutionary approach to medical education at McMaster University Faculty of Medicine in the early 70's. The Project for Learning Resources Design (PLRD), headed by Howard Barrows, M.D., was established to develop problems that would challenge problem-solving skills. The PLRD used a ten-week neuroscience unit in the McMaster curriculum as its laboratory school. Concurrent with the development of a series of problem simulations, the PLRD also became concerned with finding more effective ways to structure Problem-Based Learning and to prepare teachers to be facilitators of learning. The PLRD established a series of teacher development workshops for intramural and extramural teachers. Teachers from other medical schools found Problem-Based Learning appealing and attended these workshops in increasing numbers. As a consequence, Problem-Based Learning extended to other medical schools and has been adopted by many medical schools in the United States and throughout the world. Although there are many versions of Problem-Based Learning, the one described has been developed as a model at Southern Illinois University School of Medicine and used in their parallel Problem-Based Learning Curriculum.

The application of this model of Problem-Based Learning to elementary and secondary schools was initiated in the early 80's for the teaching of human biology (anatomy, physiology) in the innovative BioPrep program of the Josiah Macy Jr. Foundation, a health careers program for minority and economically disadvantaged high school students. More recently, SIU School of Medicine has been extensively involved in the application of Problem-Based Learning to all areas of elementary and secondary education, including all subject areas and ability levels. A two year project supported as a collaborative effort between SIU School of Medicine, Ventures in Education, a not-for-profit foundation established by the Macy Foundation and Springfield Illinois Public School District was dedicated to working with high schools with a large percentage of minority and educationally disadvantaged students. Support in the application of Problem-Based Learning to elementary and secondary schools has continued through workshops and consultation provided by SIU School of Medicine faculty.

The application of this Problem-Based Learning model to other professions and educational programs has skyrocketed since its wide adoption by medical schools. Model professions education programs have been developed (for example, the Master of Business Administration program at Ohio University under the direction of John Stinson and the Physician Assistant program at Chatham College under the direction of Linda Allison) which exemplify the six dimensions of PBL discussed in this monograph. Programs as diverse as law, veterinary medicine, dentistry, nursing, social work and education are beginning to adopt problem-based learning as a way of inculturating students in the profession from the very beginning of their training and of preparing them for its inherent change and complexity. Faculty from SIU School of Medicine provides extensive training and long-term consultation and follow-up for these programs.

SIU School of Medicine, through the Department of Medical Education's Initiative for Education for the Complex and Changing Workplace, continues to use Problem-Based Learning as an education model for preparing students for the complexity and change inherent in the workplace through collaborative arrangements with educational programs at all levels B elementary and secondary, undergraduate, and professions education, both pre-service and in-service.

For further information contact:

Howard S. Barrows, M.D., Chair, Department of Medical Education Ann Myers Kelson, Associate Director PBL Curriculum Southern Illinois University School of Medicine. (217) 782-0795

Dr. Barrows is a pioneer in PBL. Starting in medical education twenty-five years ago, he has designed and developed curricula, taught, researched, consulted, and published in PBL extensively. Over the past ten years he has been actively involved in the development of PBL in other professions and in K-12 and undergraduate education.

Ann Kelson is a former public school teacher, a cognitive scientist, and the associate director of the PBL curriculum, Southern Illinois University School of Medicine. She has consulted extensively with medical schools, professional schools and in undergraduate and K-12 educational programs.