The many faces of problem-based learning: a framework for understanding and comparison

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SUMMARY There is much literature on problem-based learning (PBL), both within and outside medical education. The literature addresses such questions as what is PBL and how does it work, and many examples are given; yet it is often difficult to determine from these descriptions whether the educational approach being described is actually PBL. The goal of this article is to provide planners and/or assessors of PBL curricula with a framework that would facilitate analyses of this educational approach. We propose to categorize educational activities as PBL or non-PBL according to three core principles: (1) the problem acts as a stimulus for learning; (2) it is an educational approach, not an isolated instructional technique, and (3) it is a student-centered approach, and four criteria concerning their effect on student learning: (1) active processing of information; (2) activation of prior knowledge; (3) meaningful context; and (4) opportunities for elaboration/organization of knowledge). Beyond this, PBL curricula vary along a set of dimensions that is useful to analyze, to describe and to compare different PBL practices. The usefulness of this analytical framework is illustrated with examples from three different schools.

Introduction

The idea for this paper derives from the many reports and applications of problem-based-learning (PBL) which are emerging. There is much literature on PBL, both within and outside medical education. This literature addresses such questions as what is PBL and how does it work, and many examples are given; yet, it is often difficult to determine from these descriptions whether the educational approach being described is actually PBL. We encountered this dilemma in discussions ranging over a two-year period, in comparing the different experiences of our three schools. Our schools employ educational formats that differ along several dimensions, but are nevertheless all labeled firmly as PBL; indeed, in some schools different PBL formats coexist. This led us to consider three questions: (1) what might be the core elements that characterize this teaching and learning approach; (2) on which criteria might its effects on learning be judged; and (3) what are the dimensions that might vary yet still maintain the essence of PBL?

As a result of this work we propose to planners and assessors of PBL curricula a framework that would facilitate analyses of this educational approach. To illustrate its usefulness we apply it to examples from three different schools.

Is it possible to define what is and what is not PBL?

In the health science education literature PBL is defined or described in diverse ways. For Barrows & Tamblyn (1980) it “is the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus or stimulus for the application of problem solving or reasoning skills, as well as for the search for or study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved”. Albanese & Mitchell (1993) define PBL as “an instructional method characterized by the use of patient problems as a context for students to learn problem-solving skills and acquire knowledge about the basic and clinical sciences”. For Vernon & Blake (1993) PBL is “a method of learning (or teaching) that emphasizes (1) the study of clinical cases, either real or hypothetical, (2) small discussion groups, (3) collaborative independent study, (4) hypothetico-deductive reasoning, and (5) a style of faculty direction that concentrates on group process rather than imparting information”. Schmidt (1993) defined PBL as “an approach to learning and instruction in which students tackle problems in small groups under the supervision of a tutor. In most of the cases, a problem consists of a description of a set of phenomena or events that can be perceived in reality. These phenomena have to be analyzed or explained by the tutorial group in terms of underlying principles, mechanisms or processes.”

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The above definitions have common ground, but they also include differing and disputable elements. For instance, the capacity of PBL to enhance the acquisition of problem-solving skills is disputed by Norman (1990). Also debated are the necessity of using clinical cases as the problems, and whether the required task is explanation, diagnosis, or planning of treatment. Even the use of small groups is subject to question (Boud & Feletti, 1991). Thus, if a PBL practice does not meet all the criteria used in any of the above definitions, an issue arises: is it PBL or not? Similarly, while PBL was designed first for preclinical health science education (Berkson, 1993) the method is now used in very different disciplines, such as architecture (Maitland, 1991), law (Winsor, 1991) and economics (Foster & Gilbert, 1991) and in medicine it is now used in clerkship (Chamberland et al., 1992; Schwartz et al., 1992), in residency (Foley et al., 1993) and in continuing medical education (Premi et al., 1994).

The range of existing definitions illustrate how difficult it is to reach a single encompassing definition. According to Boud & Feletti (1991), an educational approach as rich and diverse as PBL is difficult to circumscribe within the constraints of a short definition. It is more feasible to specify what most educators believe constitute its core, distinguishing principles. At this level, PBL can be articulated around two main principles: first, the starting point for learning should be a problem, a query or a puzzle that the learner wishes to solve; second, it is an educational approach, rather than a technique that is used sporadically in an otherwise traditional educational program. To these two principles we would add a third that is explicit or implicit in all the above cited definitions: PBL is fundamentally a learner-centered, rather than a teacher-centered approach. Each of these principles requires clarification.

According to the first principle, the PBL process begins with problems rather than with exposition or prior learning of disciplinary knowledge (Barrows & Tamblyn, 1980; Ross, 1991). The work on the problem is used explicitly to have students themselves identify and search for the knowledge they require to address the problem. That is, knowledge arises from work on the problem. This is in contrast with those settings where students are expected to solve problems using knowledge they have previously acquired, such as in the case study method (Christensen, 1987).

The second principle emphasizes PBL as a way of constructing teaching and learning experiences within courses and curricula, using problems as the stimulus and focus for student activity. It arises from an educational view that incorporates learning as central to the educational process, and the learner as an active, self-directed participant in that process. It is not simply the addition of problem-solving activities to otherwise discipline-centered curricula (Boud & Feletti, 1991). Therefore PBL is an educational approach to a domain of knowledge rather than an isolated technique of instruction (Walton & Matthews, 1989; Engel, 1991). For example, a program that comprises many lectures, and in which a few problem-based activities are incorporated, would not be a PBL program, because most of the content of the domain is acquired through a traditional didactic approach.

Third, PBL is a student-centered educational approach. In its ideal form, this would suggest that students define for themselves their learning needs, choose the means of learning that are the most appropriate to them and decide when they know enough about the specific learning need (Knowles, 1975). While such control over all parts of a learning project is appropriate in continuing medical education (Bennett, 1991), and may be feasible in more advanced levels of medical education, this is not the case in initial professional education. Students generally have had little professional experience, and are unable to define for themselves the knowledge and expertise needed for competent practice, or to evaluate its achievement. PBL is an approach that empowers students in their learning processes, but this is not an all or nothing matter: depending on the domain and the stage in students’ competence development, the student self-directedness may vary in formulation of appropriate learning objectives, choice of learning resources, determination of the depth of learning, and self-assessment of learning activities.

Presence of the three core principles however, provides only the assurance that the environment is one in which PBL can occur. To examine the effectiveness of the process requires not only knowledge of these conditions, but a close analysis of various dimensions of PBL and of the outcomes which are based on student learning, in the context of the process described. A brief overview of these principles is essential.

PBL as a learning approach

From cognitive theory (Tardif, 1992; Gagné et al., 1993; Schmidt, 1993; Regehr & Norman, 1996) a few principles are regularly identified as important to improve the efficiency of learning practices. Four of them are presented briefly and may serve as a basis for analysis of the value of PBL activities. They are as follows:

1. learners are active processors of information;
2. prior knowledge is activated and new knowledge is built upon it;
3. knowledge is acquired in a meaningful context;
4. learners have opportunities for elaboration and organization of knowledge.

Knowledge cannot be transferred directly from the mind of teachers to the mind of learners. Learners are active builders of knowledge. This means that they must actively engage with the knowledge they are acquiring, creating and manipulating. To ensure that information will be retrievable when necessary, new information must be embedded meaningfully in relevant, previously existing knowledge. Learning that occurs in a meaningful context will also be more easily retrieved than that which is acquired in isolation. The similarity between the context for learning and the context of future application facilitates the transfer of knowledge. However, many different contexts must be experienced in learning to build a fund of connected, usable knowledge.

Research on medical reasoning has shown the importance of the organization and structure of memory to explain differences among novices and experts (Elstein et al., 1978; Barrows et al., 1982). One way of expressing this
organization is the notion of memory structures called semantic networks (Regehr & Norman, 1996). A semantic network is an elaborate set of meaningful connections among abstract concepts and/or specific experiences. The acquisition of expertise in an area can be characterized by the development of rich semantic networks, which are adapted to the tasks in that domain of expertise (Feltovich, 1983). Hence, initially a novice has only a few related concepts. With experience, new concepts and concrete examples are added to the network and new, stronger, richer connections are made between existing concepts and examples (Regehr & Norman, 1996). The challenge for educators is then to help students to build and develop rich semantic networks of knowledge that are well fitted for realization of their future tasks as physicians.

We propose that after a verification of the presence of the three core principles that belong to the teaching perspective of PBL, an appreciation of the effect of PBL on students’ learning can be sought through these four criteria. Evaluating each is a value judgment; however, no analysis of PBL activity can exclude assessment of what learners do in the process. This constitutes the essence of the whole process. PBL curricula are consuming in resources and this investment is worthwhile only if the process improves student learning.

Three curricular formats of PBL

Very different educational practices can respect the three core principles of PBL and induce significant learning. To illustrate, we will present three formats of PBL, drawing on each of our own settings. They are: learning normal physiology at Memorial University, learning sciences basic to medicine at Dalhousie University, and learning in the clinical setting at the University of Sherbrooke. All of these formats are employed at the undergraduate medical education level.

Learning physiology in Memorial University

In the first year introduction to physiology course (Hansen & Roberts, 1991), a physiologist leads the entire class of 60 students in a discussion based on students’ own experiences, such as fainting or being cold. Or, students may have been subjects in a physiology laboratory, and they will discuss the collated class data. For example, in a laboratory session on exercise, students identify related physiology topics that require explanation and then work individually or in self-determined groups to research the topics. After 3–5 days, student groups meet with physiology tutors to discuss their findings.

Learning basic sciences at Dalhousie University

In Dalhousie, the first two years of the curriculum are almost entirely problem based. Students are introduced to the traditional basic sciences, and to the other sciences basic to medicine through the study of problems developed to promote learning in a clinical context. Problems have been developed to incorporate the curriculum objectives. The tutorial process, which is scheduled for six hours weekly in both years, is the heart of the curriculum. Tuto-rial learning is augmented by a small number of lectures weekly (3–5), laboratory, and introductory clinical experience. Students work in groups of seven or eight for up to 10 weeks, at which time the groups are reassigned. Tutors, who work with a group from four to 10 weeks, play a facilitative role for which they are trained. They are about evenly divided between expert and non-expert in the area in which they are tutoring. Core objectives are determined by the faculty, and provided to the students at the end of each case. Resources are provided through adjunctive learning activities as above, and through the availability of subject experts for each case or unit.

Learning clinical reasoning at Sherbrooke University

At Sherbrooke, teaching and learning in the MD program are accomplished with three different PBL formats. For the clinical years, a format has been specially designed to teach and learn clinical reasoning (Chamberland et al., 1992). The format, called ‘Clinical Reasoning Learning’, is grounded in the hypothetico-deductive model of clinical reasoning (Elstein et al., 1978), characterized by early generation of hypotheses and their iterative evaluation during investigation. In each session a clinical problem is simulated and all the processes used in a medical encounter, from diagnosis to investigation and treatment, are carried out by a small group.

The method is an adaptation of the method described by Kassirer (1983) for ward clinical teaching. A member of the group has previously either evaluated a patient or taken knowledge of a case from the data bank, and therefore has full knowledge of all the pertinent case-related data. This student acts as ‘dispenser of data’ and only reveals information in response to the explicit requests of group members. Each member in turn leads the problem-solving activity. Any question relevant to the clinical situation may be asked, but, each question must be justified and the collected information must be interpreted. What hypotheses does the student have in mind? Why ask this question? Does the new information change the diagnostic hypotheses? This method enables students to reconstitute a clinical case in a way that brings forth the intermediary steps critical to clinical reasoning. Each session is a collaborative problem-solving activity in which students progress with the help of a tutor.

Selected dimensions of PBL

Works from Barrows (1986), Ross (1991), Savoie & Hughes (1994) have shown that PBL can vary along several dimensions. For the purposes of this paper, we propose to examine 10 dimensions and to illustrate how practices vary for each of them within the three educational formats described above.

(1) The person or group who selects the problem

Ross (1991) suggests that problems may be selected by the curriculum design team, based on their view of what the students need to know; by the team, using problems suggested by student; or by the students themselves. This choice may be affected by the level of the student, es-
pecial as the student gains more experience, and is expected to be more self-directed, particularly during the clinical years.

For Memorial, general topics are selected by faculty but specific cases come from students’ own experiences or from their laboratory exercises. For Dalhousie, problems are selected by the faculty, to incorporate overall curriculum and course objectives. There is an attempt to have problems represent important health problems, which will also provide an entry point for learning important physiological, biochemical, immunologic and pathophysiological concepts. At Sherbrooke, the problems are selected from the clerkship educational objectives, which define the most important clinical presentations and clinical entities students are expected to master at the end of each clerkship rotation. The problems are prototypical and have been judged to be essential after systematic consultation among professors of the discipline. However, the specific problems discussed in the sessions could come either from a bank of problems or from recently seen cases.

(2) The purpose of the problem

Ross (1991) outlines several purposes that problems may serve. They include: to ensure that students cover a predefined area of knowledge; to help students learn an important set of concepts, ideas and techniques; to lead students to certain parts of the field; to take advantage of relevance or intrinsic interest; and to present a problem that is typical of the problems of the profession. These purposes appear to address mainly content; however, the purpose of selecting problems as a stimulus for learning reflects an understanding that learning in context is educationally effective and assists in the retention and retrieval of information (Regehr & Norman, 1996). Moreover, the similarity of the problem to those that the professional is likely to encounter in future practice is important in the future application of knowledge and skills to new problems. Therefore, selecting problems that are typical of the profession, but that also stimulate learning of important concepts and acquisition of required knowledge, are all important purposes to be considered.

At Memorial, the problem is intended to lead to study of the normal function of the human body, to explain physiological responses to everyday human situations, and to analyze critically physiological data. At Dalhousie, problems are developed to provide the students the opportunity to acquire relevant knowledge of the sciences basic to medicine, in the solution of relevant clinical problems. A related objective is that the problems will foster the development of clinical reasoning. At Sherbrooke, the problems are intended to foster the development of clinical reasoning, and to promote the acquisition of essential clinical knowledge in investigation and therapeutics for selected pathological entities.

(3) Nature of the educational objectives and control over their selection

In PBL, objectives may exist at the program, course and problem level. While there is support in the literature for the narrowing effect of faculty-derived objectives on student learning and self-directedness (Blumberg et al., 1990), it is clear that curricula are developed with faculty objectives in mind (Barrows, 1994), which, in turn, guide the selection of each problem. These objectives relate both to informational content and to process.

Depending on the balance of student versus faculty control over the process, examples exist of objectives being provided before, during and at the end of each problem. Barrows (1994) argues for students being provided with broad objectives at the start of a course unit, and for allowing them to select the order in which they are addressed. In other settings, objectives provide a common validation of what the students have studied in addressing the problem, and outline the expected knowledge that is to be acquired through study of the particular problem (Mandin et al., 1995).

In the first all-class session at Memorial, a faculty member leads the discussion by questioning to ensure that desired topics are identified. In the second small-group session, faculty ensure that students misconceptions are resolved. Dalhousie’s aim is that the process will be student-centered. In keeping with this aim, the control of the sessions and the process shifts from the tutor to the students very early in the curriculum. Even in a facilitative role, however, the tutor has the responsibility to assist students to achieve the problem objectives. At Sherbrooke, the tutor, who is always an expert in the field, has a shifting role within the session. At the beginning the role is mainly facilitative while students collect clinical data and conduct their diagnostic reasoning. As the process moves toward strategies for investigation and treatment, the tutor becomes more of a content expert who makes his/her knowledge-in-action explicit, while students pursue aloud the problem-solving activity. The variation in the degree of student’s control among the three PBL practices illustrates how dimensions vary along a continuum.

(4) The nature of the task

In cognitive psychology a problem is said to exist whenever someone has a goal and has not yet identified a means for reaching that goal (Gagné et al., 1993). This simple definition raises important issues concerning PBL. First, students must have motivation to solve the problem; they must find it relevant to their goal of becoming physicians. Second, a problem is not ‘good’ or ‘poor’ in and of itself: its effectiveness depends on the level and educational needs of the student. A problem that is challenging to first-year students may not be so for second-year students, who already understand and know solutions to the problem. A final issue concerns the goal itself, the nature of the task required of the students. Depending on the curriculum, the task could vary considerably. It could be to explain a phenomenon, to make a diagnosis, to plan investigation and treatment, or any other task that is relevant for future physicians. The critical aspect is the relevance of the task. Important also is that both students and tutors must have a clear idea of the task to be done. This may seem obvious, but observations of existing PBL groups (at least in a 1996 informal survey in one of our schools) have shown a lack of goal clarity. In fact there are two tasks in any PBL activity. The first is to identify and solve the
problem at hand (for instance provide a clear description of the pathophysiological processes that explain an illness presentation), and the second is to identify, search out and learn the knowledge required to understand and solve the problem. There is often a lack of understanding that these two tasks coexist and that both must be addressed.

(5) The presentation of the problem
Problems appear in many formats, from a paper case, to a simulated patient or to a real patient. In paper cases, the problem may appear as an event, a descriptive statement or a set of questions. Its goal is to stimulate both activation of existing knowledge and identification of areas where further information and comprehension are needed. Coles (1991) has suggested that problems should begin with the most controlled presentation, as in a paper case, and move to more realistic true-to-life problems as students progress through the curriculum. Presentation is affected by the level of the student for whom the problems are written or selected, the process that the students undertake in addressing the problem, and the degree of learner vs. teacher centeredness of the curriculum. Barrows (1994) describes a problem presentation which mimics practice as closely as possible. In the practice setting, problems are usually characterized by conditions where (1) there is insufficient information on which to make decisions; (2) the nature of the problem changes as more information is available; (3) at some point the student must make a decision based on the information they have available, and (4) the patient must be included as a partner. In Barrows’s model, information is available to the student only as he or she requests it, not as the faculty thinks it should be given to students. In other models, more information is made available as the case unfolds; the information available is not affected by the questions that the student may ask or by an expressed need for information.

The task of Memorial students is to explain physiological data and describe the human body’s normal physiologic functions; the specific problem originates from students’ own experiences in life and in the physiology laboratory. At Dalhousie, paper-based problems are presented. Occasionally, the first encounter with a problem will be with a real patient who visits the class. Students’ tasks are to explain the normal and abnormal mechanisms of the body’s response that underlie the patient’s problem. At Sherbrooke, a student plays the role of a patient and provides data in a manner similar to how a patient might do so in a real clinical situation. Participants must collect data, make a diagnosis and then plan investigation and treatment for the patient’s condition. All three settings promote active use of students’ existing knowledge.

(6) Format of the problem
Problems may be developed to extend over one, two or three sessions, to be studied once, or to be revisited at different levels of the curriculum. This is affected by curriculum objectives. In some cases the focus may be on fewer, more complex cases; in others, more, shorter cases are included to provide more exemplars, with the aim of enhancing problem solving when new problems are encountered. The format depends also on the nature of the information to be acquired. In preclinical education there is a need to look for information that is in textbooks, journals, etc., while in clinical training, strategies are sought to solve clinical problems which may not be found in books but must be made explicit from the minds of experts. Schön (1987) identifies a need for practice sessions that simulate real practice formats, adapted for professional education. Such sessions can be organized at the levels of undergraduate, graduate or continuing medical education.

At Memorial, problems extend over two sessions between which students find and apply information to explain the problem, whether it has arisen from a human situation or from a class laboratory experiment. At Dalhousie, problems are designed to extend over three sessions. The time between each of the sessions is available for the pursuit of learning issues, the information from which is to be applied to the problem in the tutorial. Other, briefer ‘mini-cases’ are added to enrich certain areas. At Sherbrooke, learning occurs during one session only. No preparation is required for the session. Students address the patient problem with the knowledge they already have, as they will do in a real clinical encounter. When they stop progressing by lack of knowledge or by taking false tracks, the tutor intervenes. At the end of the session students may have perceived they have significant lacunae in their clinical knowledge base and may decide to work to correct it, but this is an individual student decision.

(7) The processes students follow
Ross (1991) delineates three different options for these processes: he includes students working individually, in groups with a tutor, and in groups without a tutor. While these are separable as approaches, most PBL formats probably combine both individual and group work. In the literature, PBL processes are most often associated with small groups, usually ranging in size from four to eight students for maximum effectiveness. There are two aspects that are often associated with PBL but may or may not be incorporated in the processes undertaken by the students. The first is the notion of self-directed learning. For Barrows (personal communication, 8 May, 1997), this is an essential element of PBL. Problem-based learning processes are self-directed to the extent that learners identify the areas for learning raised by the problem, formulate them into relevant questions, search out resources, and apply the new knowledge to the problem. Clearly, all three options may allow for self-directed learning. Second, another aspect of PBL that is implicit in its structure is the opportunity for elaboration of new knowledge through discussion and exchanges (Coles, 1990; Schmidt, 1993). This process, while possible independently, is enhanced when students work in groups (Dolmans, 1994). The opportunities to challenge and verify information for its accuracy are greater when encountered in a group than by individuals.

For Memorial, the first session involves the entire class in a large group. The teacher draws out students’ descriptions of their responses to a given situation and, led by questioning, students suggest the physiologic topics that
must be explored to explain the responses. Students learn about these physiology topics during the next few days and report their understanding during the second session 3–5 days later, in groups of 6–8, each with a tutor. Tutors both facilitate the discussion and explain any concept that cannot be explained by students (a rare occurrence). At Dalhousie, three two-hour sessions are held on Monday, Wednesday and Friday of each week. All groups work concurrently on the same problem, which usually lasts three sessions. Initial sessions with the problem focus on analyses of problem components and generation of hypotheses. Students are encouraged to be as creative as possible, drawing on their prior knowledge; tutors play a facilitative role. Students identify learning issues to be pursued between sessions. In the second and third sessions, students elaborate (Coles, 1990; Bordage, 1994) on newly acquired knowledge, validate it through discussion with peers, and refine their hypotheses based on new information. At Sherbrooke, activities extend over one session, and include thinking aloud and problem-solving activity. Discussion is structured, and students take the lead one after another. As in a clinical encounter, there are not several interviewers asking the patient questions in random order, but there is a physician who follows a line of ideas. The process here tries to reproduce authentic professional situations.

(8) Resources utilized and how they are identified

In this dimension we refer to learning resources that students use to augment their study and to address the learning needs raised by a problem. Resources may be identified for the students by the problem designer and provided to all students. The designers may also identify a variety of resources and students, as individuals or groups, may draw on them as they see the need. Students may also be responsible for identifying their own resources, in the interest of providing the most freedom for different learning approaches and the most encouraging environment for development of self-directed learning skills. The choice here is affected by the degree to which the learner is considered responsible for his/her own learning. However, there are arguments to support a gradual increase in the responsibility given the student for identifying and analyzing the value of resources. Early in the PBL process students may need assistance in identifying and accessing appropriate resources, while later on this assistance may be unnecessary or undesirable.

At both Memorial and Dalhousie, the primary purpose is to promote students’ acquisition of declarative knowledge, i.e. knowledge of organ descriptions, laws of physiology, rules of scientific reasoning and understanding of basic mechanisms. Such knowledge can be obtained from many sources: e.g. books, journals, audiovisual media and experts. The PBL goal here is that students perceive the relevance of knowledge they require, choose the media appropriate to their learning style (suggested resources are put on reserve at the library, and experts are available for consultation), learn alone or in collaboration with peers and then meet again to share knowledge while solving the problem at hand. There are experts available to assist students in every case. At Sherbrooke, the purposes are acquisition of declarative (facts and rules about diagnosis and management of diseases) and procedural knowledge (knowledge concerning strategies used in clinical reasoning). Students can progress quite far unassisted in the data collection process and in the diagnostic reasoning. When a student runs out of ideas, the lead is taken by another, and so the process is cooperative problem solving. When the clinical process comes to strategic choice of investigation means and of treatment, medical students often lack the clinical experience needed; hence, tutors often assume a role of resource person.

(9) The role of the tutor

Generally, the role of the tutor in PBL is characterized by interaction that is facilitative rather than directive, and in which information giving by the tutor is subordinate to assisting students in the process of activating, identifying, accessing, analyzing and applying information, and of developing reasoning processes and knowledge structures.

At Memorial the tutor acts as both content and process expert. At Dalhousie, the tutor is a facilitator, and is not expected to be a content resource. The tutor’s role is to enhance the process, modeling the various steps of the reasoning process, navigating the group through the iterative process, and eventually fading, as the students acquire experience with the process. In the second and third sessions, along with their facilitative role, tutors take care that no misconceptions develop. At Sherbrooke, because the main objective of these sessions is to uncover knowledge-in-action (Schön, 1987), the tutor is always an expert in the field. As clinical expertise is very content-dependent, one cannot teach clinical reasoning if he/she is not an expert in the field. This does not mean that the tutor becomes a lecturer; rather, care is taken that tutors guide students’ reasoning through questioning.

(10) Demonstration of learning through a product or a performance (assessing students’ achievement)

If we regard the learning process as systematic, then no discussion is complete without consideration of the role of student assessment in PBL. Two main issues are noteworthy. The first addresses assessment of individual learning, with a need for methods that are consistent with the learning and teaching method. The second is the assessment of the quality of the group’s work in its problem-solving activity. Assessment plays an important role in determining what students actually do in any type of program. If achievement of an important part of an educational process is not assessed, that aspect of the process is at risk of neglect by the student. In our experience it can happen that PBL sessions are used by students to uncover, as quickly as possible, what they should learn, and in doing so, important parts of the process are glossed over, i.e. the practice of working through the problem.

In the three illustrative curricular formats, students demonstrate their learning through a product that is related to the task represented by the problems. At Memorial students’ performance is assessed using problem-based written examinations, including a multiple-choice questions. At Dalhousie,
Table 1. An illustration of variation of PBL practices along the 10 dimensions.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>(A) PBL in basic sciences (at Memorial U.)</th>
<th>(B) PBL in basic sciences (at Dalhousie U.)</th>
<th>(C) PBL to learn clinical reasoning (at Sherbrooke U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Problem selection</td>
<td>Planners</td>
<td>Planners</td>
<td>Planners and tutor</td>
</tr>
<tr>
<td>(2) Problem purpose</td>
<td>Basic sciences</td>
<td>Underlying mechanisms</td>
<td>Clinical reasoning</td>
</tr>
<tr>
<td>(3) Student vs teacher control</td>
<td>Normal physiology</td>
<td>Teacher and student control</td>
<td>Solve a patient problem</td>
</tr>
<tr>
<td>(4) Nature of the task</td>
<td>More teacher than student</td>
<td>Explain and describe</td>
<td>More teacher than students</td>
</tr>
<tr>
<td>(5) Presentation of the problem</td>
<td>Lab data or students’ experience</td>
<td>Paper based</td>
<td>Diagnose and manage</td>
</tr>
<tr>
<td>(6) Problem format</td>
<td>Two sessions</td>
<td>Three sessions</td>
<td>Patient simulation by a student</td>
</tr>
<tr>
<td>(7) Process followed</td>
<td>Entire class with tutor, then group with tutor</td>
<td>In group with tutor</td>
<td>One session</td>
</tr>
<tr>
<td>(8) Resources</td>
<td>Peers’ knowledge and available information</td>
<td>Peers’ knowledge, texts, subject experts</td>
<td>Peers’ knowledge and expert from the domain</td>
</tr>
<tr>
<td>(9) Role of tutor</td>
<td>Facilitator and content expert</td>
<td>Facilitator</td>
<td>Facilitator and content expert</td>
</tr>
<tr>
<td>(10) Demonstration of learning</td>
<td>Explain normal physiology</td>
<td>Explain underlying mechanisms</td>
<td>Diagnose, plan investigation/treatment</td>
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Demonstration of learning is evaluated in both written examination and tutorial performance. Students must be successful in both evaluations to complete a unit. Evaluation of tutorial performance validates the importance of acquiring the skills to work effectively in a team, as well as the acquisition of content knowledge. At Sherbrooke, learning is demonstrated by the production of a diagnosis, investigation and treatment plans adapted to the patient problem.

Conclusion

The three described educational activities from three different schools in different settings with different goals illustrate the many different faces PBL can present. All of them, according to the analytic framework, represent true PBL but they vary considerably along the 10 selected dimensions. The framework allows their analysis and in this process we, as authors, learned much about the nature and characteristics of our own educational activities and have found the use of these criteria and dimensions very helpful.

There are several ways in which the above framework might be useful to those in medical education. First, we believe the framework has utility for those curriculum planners deciding whether and how to use PBL in their particular setting. A clear description of the various dimensions of PBL can raise awareness of the various aspects that require attention when making decisions about PBL: additionally, it can assist planners to decide which outcomes can be achieved in their setting with the resources available to them.

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