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A taxonomy of problem-based learning methods

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Summary. The increasingly popular term 'problem-based learning' does not refer to a specific educational method. It can have many different meanings depending on the design of the educational method employed and the skills of the teacher. The many variables possible can produce wide variations in quality and in the educational objectives that can be achieved. A taxonomy is proposed to facilitate an awareness of these differences and to help teachers choose a problem-based learning method most appropriate for their students.

Key words: *Problem-solving; *Education, medical; *Learning; Teaching/methods; Illinois

Introduction

A wide variety of educational methods are referred to as problem-based learning (PBL); methods that can address quite different educational objectives. The common denominator is the use of problems in the instructional sequence. The problems used can also vary as posed questions, unexplained phenomena, or patient and community health problems. The patient problems can be short case vignettes, complete case histories, or problems simulated in a variety of formats. Historically, the term PBL has been used in a very non-specific manner and, as a consequence, medical teachers do not perceive the differences in educational objectives that may be addressed by different approaches. A particular PBL method is often chosen because of ease of use, perceived feasibility, or low cost without realizing the educational sacrifices made when compared to other methods. Students who have had unsatisfactory experiences with one variety of PBL may paint all PBL methods with the same brush. A taxonomy is proposed to help teachers and students appreciate the comparative value of different methods.

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Educational objectives possible with PBL

Depending on the specific educational design, a PBL method has the potential to address a number of objectives important in medical education (Barrows 1985). These objectives are not well addressed by more commonly used educational methods. The more important ones are:

(1) *Structuring of knowledge for use in clinical contexts (SCC).* Education is most effective when it is undertaken in the context of future tasks (Glaser 1982). To facilitate the subsequent recall and application of information, from *both* the basic and clinical sciences, to future clinical work learning should occur in clinical contexts. Learning that is driven by challenge of practice and integrated into the reasoning required to evaluate and resolve patient problems promotes structuring of knowledge to support practice (Glaser 1982; Schmidt 1982).

(2) *The developing of an effective clinical reasoning process (CRP).* The problem-solving skills involved in the clinical reasoning process have to be shaped and perfected through repeated practice and feedback to be effective and efficient. These skills, including hypothesis generation, inquiry, data analysis, problem synthesis and decision-making, must be developed in association with the acquisition of basic science

and clinical information to ensure that problem-solving and knowledge will work together in the clinical setting (Simon 1980; Glaser 1982; Feltovich *et al.* 1983). Properly designed, PBL can feature problem simulations that allow this to occur (Barrows & Tamblyn 1977; Distlehorst & Barrows 1982).

(3) *The development of effective self-directed learning skills (SDL).* Skills of self-assessment and self-directed learning allow the student to become sensitive to personal learning needs and to locate and to use properly appropriate information resources. These are essential skills for doctors, as medical knowledge moves ever onwards and new problems and concepts, never envisioned or predicted by medical school teachers, will have to be understood and applied in the care of patients.

(4) *Increased motivation for learning (MOT).* Motivation enhances student learning (Katona 1940). The perceived relevance of work with medical problems and the challenge of solving problems provide strong motivation for learning.

Although there are other objectives that can be accomplished with PBL, these are of primary importance. The clinical reasoning process (CRP) and self-directed learning (SDL) represent essential capabilities for the doctor which students need to practise and perfect under guidance of teachers. The structuring of information in a clinical context (SCC) enhances retention, recall and application of knowledge in clinical work. Motivation (MOT) increases an internal drive for learning and facilitates extraction and understanding of information from learning resources (Berner *et al.* 1974).

The intent of the proposed taxonomy is to identify the degree to which these objectives are addressed, if at all, in either the design or the execution of various methods referred to as PBL.

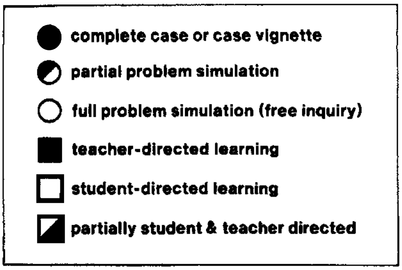


Figure 1. Variables in problem-based learning methods.

Major variables in PBL design (see Fig. 1)

The design and format of the the problems used in PBL is a major variable (represented in Fig. 1 as a circle). In many varieties of PBL, students are given a case history or case vignette that provides an organized summary of the facts they need to know about the problem (solid circle). The students' challenge is to decide what may be going on in the patient and what should be done on the basis of the evidence provided. In other varieties of PBL students are given the initial presentation of the problem and have to assemble the important facts through free inquiry, as occurs in the real world, using clinical reasoning (empty circle with a filled-in corner representing the presenting complaint). In some instances the problem format is a compromise between these two extremes—a number of the facts in the case are provided and the students have to decide on a limited number of inquiry actions or decisions, as in the sequential management problem (SMP) (Berner *et al.* 1974)—or to choose actions and decisions from alternatives presented, as in the patient management problem (PMP) (McGuire *et al.* 1976). Following each opportunity for these limited decisions students are provided with more information about the problem, related to their inquiry in the PMP and unrelated to their inquiry in the SMP (both indicated by a circle half solid and half empty).

The degree to which learning is teacher-directed or student-directed is another important variable. The teacher usually determines the amount and the sequence of information to be learned in the domain of the course (a solid square). However, in some methods students may be given this responsibility, guided by tutors using facilitatory teaching skills, by the selection and design of the problems offered in the course, and by course objectives (an empty square). The sequence in which problems are offered and information is acquired represents a third major variable (indicated by arrows).

PBL taxonomy

The possible permutations and combinations of design variables in PBL are endless. The particular entities in this taxonomy were chosen because they represent varieties commonly in use. The degree to which each of the four educational objectives (SCC, CRP, SDL, MOT) are addressed by the educational design is estimated by a score of 0–5, justified in brief narratives. The scores are used only to indicate the comparative power of each method in relation to the particular objective.

Lecture-based cases (Fig. 2). The teacher presents the students with information in lectures and then a case or two, usually vignettes, to demonstrate the relevance of the information. This frequently used method is occasionally referred to as PBL. It does not directly foster any of the objectives listed. At best, students are asked to understand the cases presented in terms of the information in the lectures, and some of that information may be restructured by students. Some hypothesis generation, data analysis, and limited decision-making may be required. No inquiry, or case-building skills, are needed.

SCC: 1 CRP: 1 SDL: 0 MOT: 1

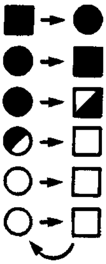
Case-based lectures (Fig. 2). This is not the 'Case method' described next. Students are presented with case vignettes or more complete case histories before the lecture. The cases highlight material to be covered. Students' prior study of the case challenges the same amount of clinical reasoning as described before. The students have to analyse the case using their prior knowledge, before any new knowledge is provided. This effort should cause some clinically oriented structuring of the subsequent information provided in lecture, as opposed to possible restructuring of information already provided, as may occur in the lecture-demonstration method above. There is no self-directed learning, unless through curiosity the student looks up some resources to understand the cases better.

SCC: 2 CRP: 2 SDL: 0 MOT: 2

Case method (Fig. 2). A method with a long and venerable history; largely identified with law and business although it has been used in medical education (Cabot 1906; Cannon 1980). Students are given a complete case for study and research in preparation for subsequent class discussion. This gives SDL a strong, but not full, score. The subsequent interactive case discussion in class, facilitated by the teacher, in a tutorial role, combines both student-directed and teacher-directed learning. This is a stronger challenge to hypothesis generation, data analysis and decision-making with more active structuring of information in a clinical context. It is a more motivating method. However, the case material is already organized and synthesized for students, thus limiting the amount of reasoning which will occur.

SCC: 3 CRP: 3 SDL: 3 MOT: 4

Modified case-based (Fig. 2). This is the method often used in new medical schools which feature PBL. SMPs, PMPs or similar problem formats are usually employed in small



	SCC	CRP	SDL	MOT
lecture-based cases	1	1	0	1
case-based lectures	2	2	0	2
case method	3	3	3	4
modified case-based	4	3	3	5
problem-based	4	4	4	5
closed-loop problem-based	5	5	5	5

Figure 2. Problem-based learning method varieties (see text).

tutorial groups. More elements of the CRP are challenged than in the previous methods as students also decide on inquiry actions. The cueing and restricted inquiry possible in the usual PMP, and the lack of follow-through on the students' proposed inquiries in the SMP, prevent employment of the full CRP. In most of these schools skill in self-directed learning is an objective and their use of this method is designed to address SDL directly. However, a full score for SDL does not seem warranted as the students do not know what additional information they might need if they had to carry out the full and free inquiry that occurs in the clinical situation. Further, both CRP and SDL are not fully addressed because the students are not required actively to apply the results of learning as, for instance, reasoning through the problem again. More clinical structuring in memory occurs through the combination of CRP and SDL. It is highly motivating.

SCC: 4 CRP: 3 SDL: 3 MOT: 5

Problem-based (Fig. 2). Students are presented with the patient's presenting picture in simulation formats that allow for free inquiry (Barrows & Tamblyn 1977; Distlehorst & Barrows 1982). They can employ all the steps in the CRP to establish the data base relative to their hypotheses. There is usually an active, teacher-guided exploration and evaluation of the problem, using facilitation or tutorial skills, which directly activate the student's prior knowledge, much of which may otherwise be beyond conscious recall, for review and association with new learning. This activation of prior knowledge facilitates the understanding and retention of new, problem-related information (Schmidt 1982). Another advantage to this direct activation is that it can reveal prior knowledge which is incorrect and could serve as a poor foundation for new learning (McCloskey *et al.* 1980). More of the students' prior knowledge is activated in designing an inquiry strategy and the analysis of learning needs for SDL involves this as well. Nevertheless SCC, CRP and SDL should not be given full credit as the new information learned is usually not actively applied to a revaluation of the problem.

SCC: 4 CRP: 4 SDL: 4 MOT: 5

Closed loop or reiterative problem-based (Fig. 2). This is an extension of the problem-based method described above. After an episode of self-directed study is completed, the students are asked to evaluate the information resources they used and then to return to the patient problem as it was presented originally to see how they might have better reasoned their way through it and gained a better understanding, on the basis of what they learned in self-directed learning. As they do this, they are also asked to evaluate their prior reasoning and knowledge (Barrows 1985). These steps further address CRP, SCC and SDL as students have to go beyond the acquisition and discussion of new knowledge in a way that allows them to see its value and to evaluate actively their prior knowledge and problem-solving skills. Another round of self-directed learning may be needed as a result of this second problem analysis and synthesis.

SCC: 5 CRP: 5 SDL: 5 MOT: 5

Other variables effecting educational objectives in PBL

Although it was assumed, in the examples above, that the case-based method did not feature self-directed learning, it is quite possible that in some settings it does. It was assumed that the problem-based approach did, but there are instances where it does not. Self-directed versus teacher-directed learning can be a variable in the way all methods are employed by different teachers regardless of curricular design.

In some instances, the teacher feels it is necessary for the students to receive some initial information, usually in lecture format, before they begin to work with problems in the problem-based methods. This is usually done out of concern that the student must know some vocabulary and definitions, and have an overview of the subject before any meaningful problem-solving can occur. This can diminish the challenge to SDL and the degree of SCC.

The opportunity for students to have a parallel opportunity to work with real patients is another variable. This allows students to practise and transfer the knowledge and skills they have acquired in PBL to work with real patients, enhancing all of the objective.

Evaluation determines the way in which students will study despite anything teachers may say about the goals of a course. If CRP, SDL and SCC are important educational goals in any PBL method, the student assessment methods must challenge problem-solving, clinical reasoning and self-directed learning and not primarily emphasize the recall and recognition of facts (Frederiksen 1984). Without these assessments, the educational objectives for PBL are weakened as students will not honour them in their study. The teacher will never know whether the students are meeting these objectives.

The same reasoning used in the examples chosen can be applied to all such variations in PBL delivery to estimate the degree to which each addresses the four objectives.

The skill of the teacher as an uplanned variable

All the above variables are planned variables. Another unplanned variable, which has a potent effect on the quality of PBL, is the understanding and skills of the teacher or tutor. If the students are not given the freedom to reason and learn on their own because of an overly directive tutor, or if the students are not guided by the teacher to consider all the steps in the hypotheticodeductive reasoning processes, always to question whether they have learning needs as they work, and to choose and use a variety of resources in their learning, then objectives are compromised. The quality of tutorial skills is a common concern of schools that use problem-based approaches.

Feasibility and cost

Cost and feasibility are also important variables. They are easier to assess and, as mentioned in the introduction, may be the major influence in the selection of a problem-based learning method. The lecture-based method is the least expensive in terms of cost, time and effort for teachers. It requires the least effort for curriculum designers and no special teaching skills or materials. The closed loop or reiterative PBL method requires complex problem simulations for teaching and evaluation. They take time and effort to prepare. The curriculum has to be thought out in terms of objectives, choice of problems, scheduling of time and the development of resources. This method requires the teacher to have facilitatory teaching skills. The others fall in between so that the methods with the greatest educational potential are also the more difficult and expensive to mount. With PBL careful decisions about both cost and benefit have to be made in the choice of a specific method.

Conclusion

The term problem-based learning must be considered a genus for which there are many species and subspecies. Each addresses different objectives to varying degrees. All descriptions and evaluations of any PBL method must be analysed in terms of the type of problem used, the teaching-learning sequences, the responsibility given to students for learning and the student assessment methods used. Any teacher who wishes to employ PBL should decide on desired educational objectives and then select the method that fits best.

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