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# Introduction to Problem-based Learning

## A guide for students

Noordhoff Uitgevers

Jos Moust
Peter Bouhuijs
Henk Schmidt

Third edition

Introduction to Problem-based Learning

# The Higher Education Series

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# Preface

All over the world, universities and colleges are offering an increasing range of educational programmes based on the problem-based learning (PBL) approach. Problem-based learning requires students to engage in a lot of self-directed learning behaviour. This approach does not prescribe in great detail what and how students should learn. Students have to take the initiative themselves to find explanations and solve problems. Teachers facilitate and guide students in acquiring subject-matter knowledge and skills as well as helping them to become life-long self-directed learners.

Experience has shown that a good preparation for working in a problem-based learning context is important. This book is based on our long experience with problem-based learning at Maastricht University. It gives students a practical introduction to this educational approach. The book pays particular attention to the skills students need to operate within as well as outside problem-based tutorial groups. Special attention is given to methods of structuring satisfactory discussions of the various types of problems students get confronted with, as well as techniques for chairing tutorial meetings and how students can best organise their studies in a problem-based learning environment. Tips, exercises and questionnaires are designed to help readers get a better grip on their learning processes.

This third revised edition has been updated where necessary, there are some new figures included and more attention is paid to the use of computers, tablets and Internet in problem-based learning.

We would like to thank numerous colleagues and students at Maastricht University and other places around the world who have given us feedback while we were developing the components of this book. The illustrations were drawn long ago by Chris Voskamp for the very first local version. We would particularly like to thank Corien Gijsbers for adapting parts of an internal manual for students, and Mary Lawson and Andrew Davies who were so helpful in translating the first edition of this book. In revising this latest edition we benefitted a lot from critical comments of Herma Roebertsen and Marte Rinck de Boer.

Maastricht, September 2012
Jos Moust, Peter Bouhuijs and Henk Schmidt

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# 1

# Features of Problem-based Learning

## 1.1 Introduction

Read the following text carefully.

A warm summer's day
It is a warm, muggy summer's day. If you look carefully you can see great quantities of dust particles rising in the air. Towards the end of the afternoon, dark clouds start to appear and the weather becomes even more oppressive. Then there's a flash of lightning in the distance followed by a clap of thunder. Suddenly it starts to rain heavily.
Discuss these phenomena.

If you were presented with this problem as a student and stopped to think for a minute about the sequence of events described, your train of thought might go something like this:

‘I think it’s probably something to do with the causes of a thunderstorm. Static electricity is involved. Sparks bouncing off clouds of varying charges, i.e. voltage, cause the flashes of lightning described in the problem. These flashes are accompanied by a loud bang. This is probably due to the displacement of different air pockets, which are first pressed together and then expand. But why do these air pockets get pressed together? No idea. Of course, seeing the flash of lightning before hearing the thunderclap is because light travels faster than sound. Perhaps when air is moist it becomes a better conductor of electrical current, but I’m not really sure why this should lead to a difference of charges in the clouds. It’s probably something to do with the temperature. Of course, thunderstorms are more common in the summer, particularly late summer when the air is warm and muggy, than in winter. They usually occur in the late afternoon. Maybe it has something to do with those rising dust particles in the air, but I’m not at all sure what part they play. Why do these particles rise? Perhaps this is due to the heat convection from the earth’s surface. I really don’t know. And how do the clouds receive an electrical charge?’

If you could think along these lines, it would seem that you had some prior knowledge about the phenomena that you had been asked to explain. You know something about static electricity, about the causes of a thunderclap, about the different speeds at which light and sound travel through the air, and about the conditions in which a thunderstorm is most likely to occur. You might also be able to speculate about other aspects of the problem. But probably certain things really are beyond your comprehension. For example, what part is played by the rising dust particles, and how do clouds receive an electrical charge?
Did this come to *your* mind, thinking about the problem? Possibly you know more about the subject than the fictitious ‘you’ introduced above. Maybe you’ve managed to acquire more knowledge about the subject or you’re just better at establishing links between the few things you do know and the text of the problem. But, if you wanted to tackle the problem in depth and you’re not a meteorologist, no doubt you would engage yourself in the processes that cause a thunderstorm. In engaging yourself, and failing to find reasonable explanations, you might even develop a need to find out more about the processes to enable you to explain the problem better at a later stage.

This example represents the necessary ingredients of an educational method called *problem-based learning* (PBL). These ingredients are: a *problem description*, which invites further active deliberation; *prior knowledge* that is activated by the process of thinking through the problem; *questions* raised by the problem and the need – or *motivation* – to look for further information relevant to the problem at hand. When other students, who are also interested in the problem, *share* in the process of active deliberation and all this takes place *under the guidance of a tutor*, the essential elements of problem-based learning are in place. The remainder of this first chapter will discuss how these elements are built upon to form an approach to instruction that is definitely different from conventional lecture-based education.

Let’s begin by explaining problem-based learning in the context of a course or curriculum. In problem-based learning, students are brought together in small tutorial groups of about six to ten peers. During their first meeting they are confronted with *the problem* as the starting point of the learning process, even before they are presented with any course material in the form of textbooks. The problem always comes first! They are expected to discuss the problem under the guidance of a *tutor*. Initially the group will produce a *tentative analysis* of the problem based on their prior knowledge, similar to the analysis conducted in the first paragraph of this book. This tentative analysis will lead to questions about issues not understood, clarified, or explained initially. These questions will be used by the students as *learning objectives* for *self-study*. In the period that elapses before the next tutorial – usually a few days – students will work towards these learning goals, either individually or in groups, by reading books and articles, watching video tapes, consulting teaching staff etc. Following this self-study phase, the students *report back* to each other in the tutorial, sharing what they have learned and evaluating the extent to which they have attained a better understanding of the problem through their self-study (Figure 1.1).

Problem-based instruction is usually organised in a number of *modules* (or courses), each of which dealing with a particular *theme* for a number of weeks.

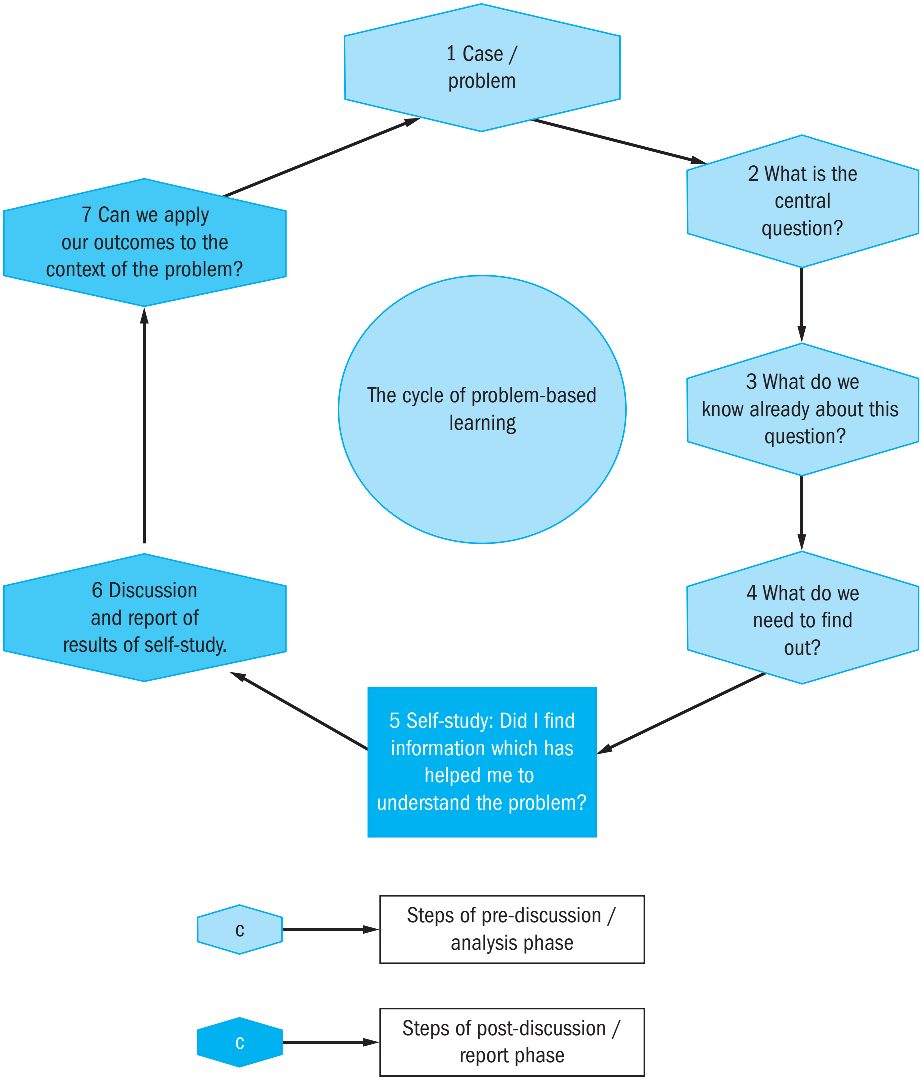
These modules are arranged sequentially to form a curriculum. It is the job of the teachers responsible for the module to compile a *module book* to be used by students as a guide to negotiating their way through the subject matter. The module book consists of a number of problems, which offer the student a way of unravelling the module's main theme. The module book may also contain a short introduction to the theme, timetables, tutorial group lists, a list of learning resources (including literature, audio-visual aids and computer programmes), as well as a summary of supplementary study activities, such as practical work, lectures, excursions and skills training. A module book is *not* a syllabus, but indicates the *way* the related contents of a particular theme can be learned without actually containing any of the subject matter itself.

Problem-based learning was first introduced in 1969 at the medical school of McMaster University in Hamilton, Canada, and has been gaining popularity ever since. Universities and colleges throughout the world are now using it as the main educational method for courses in many subjects.

In the Netherlands, problem-based learning was first introduced in 1974 in the faculty of medicine at Maastricht University. Other faculties within this university have since adopted this method of teaching, e.g. law, economic sciences, psychology, humanities and health sciences. Problem-based learning has been adopted by other universities and colleges in a wide range of disciplines, such as engineering, nursing studies, and teacher training. Presently, about 500 curricula worldwide use problem-based learning.

The founding fathers of problem-based learning have suggested that the most important potential *benefits* of the method are: that students learn to analyse and solve the relevant problems of their domain of study, that they acquire knowledge that is retained over long stretches of life and can

**FIGURE 1.1** The cycle of problem-based learning




also be actually used; and that students develop the necessary self-directed skills for life-long learning. These potential benefits can only be achieved if the student adopts an active attitude to learning. This implies inquisitiveness about the problems associated with the theme, harnessing knowledge already acquired and gaining new knowledge and skills through in-depth analysis of the subject matter. Learning – that is the acquisition, retention and recall of knowledge – within a specific context and related to particular problems is more effective than the acquisition of facts and information simply gleaned by reading a book from cover to cover.

Problem-based learning assumes that the student is able to study independently, without being constantly spoon-fed by a teacher. This emphasis on self-directed learning demands discipline on the part of the students. For example, students will have to dig deeper and wider for study material, learn to distinguish the relevant from the trivial, plot out an individual course of study, consult fellow students and teachers, and explain to fellow students what they have learned themselves.

Of course, teachers have their role to play too. They are required to present the subject matter so that students can access the subject matter effectively. They are required to guide students though the subject matter in easy-to-follow ways and to establish a clear link between the various areas of study. In the tutorial, they enable students to learn and to collaborate. In addition, teachers are responsible for assessing the achievements of their students appropriately.

## 1.2 What is learning about?

To understand how problem-based learning works, it may be useful to know a little bit more about learning in general. Therefore in this paragraph we introduce four ideas crucial to understanding what learning is all about: (1) learning as the construction of meaning, (2) elaboration, (3) learning in context, and (4) intrinsic motivation as a motor for learning.
*Learning as the construction of meaning.* For a long time, educational theorists maintained that learning is essentially a *passive* process. The mind of the learner is a blank slate on which the teacher writes the knowledge. Knowledge acquisition in this view is essentially the same as filling an empty space. The learner listens as the teacher, or the book, does its work. If the student is paying sufficient attention, learning will automatically result. This theory has been the basis of much classroom instruction. However, it has difficulty explaining why students sometimes remember what they've learned quite differently from what they've been taught, as every teacher who has to mark exams can tell you. In addition, this theory cannot explain why many students have difficulty studying and remembering a text such as the following:

> *'Nobody tells productions when to act; they wait until conditions are ripe and then activate themselves. By contrast, chefs in the other kitchens merely follow orders. Turing units are nominated by their predecessors, von Neumann operations are all prescheduled, and LISP functions are invoked by other functions. Production system teamwork is more laissez-faire: each production acts on its own, when and where its private conditions are satisfied. There is no central control, and individual productions never directly interact. All communication and influence is via patterns in the common workspace – like anonymous 'to whom it may concern' notices on a public bulletin board.* [1]

Ordinary people experience difficulty understanding this text and blame it on the way it is phrased. The text is considered 'incoherent', 'difficult', or a 'collection of sentences put together in an arbitrary way'. However, not everyone would feel this way. Computer science students, for instance, would have no difficulty recognising that the writer is attempting to characterise different programming approaches in a somewhat informal way. They are able to do so because they have the *prior knowledge* (knowledge of Turing units, Von Neumann operations, LISP functions, etc.) enabling them to interpret the text appropriately. This fact and many others have led researchers to believe that learning is not a passive process; it is not filling empty spaces, but a process by which *the learner uses prior knowledge to construct meaning*. This theory has many implications, the most important being that knowledge cannot be transmitted automatically from teacher to learner. Learning requires an act of interpretation by the learner, using whatever knowledge he or she already possesses of the topic at hand. If the person does not possess sufficient prior knowledge, learning cannot take place. In addition: those who have more prior knowledge will profit more from new learning experiences. And thirdly: prior knowledge needs to be activated by the learning situation in order to be helpful in new learning.

*Elaboration*. Having sufficient prior knowledge and having this knowledge activated by the learning situation are in themselves not enough for new learning to take place. Prior knowledge helps in the initial interpretation of new knowledge to be acquired, it helps to *understand*, but for new information to become anchored in the brain more effort is necessary. *Repetition* of the new knowledge is a much-used strategy. For instance, when English speakers in French class have to learn the French word for 'sea' ('la mer'), they resort to rehearsing both words a number of times in the hope that the French equivalent persists in memory. However, a far more effective strategy is *elaboration*. 'To elaborate' means literally 'to work out' and consists of the enrichment of the relationship between two ideas with other related ideas. For instance, if one already knows that in French 'la mère' is 'the mother,' then this knowledge can be used to construct a relationship between the sea and la mer. This can for instance be accomplished by remembering that during your holidays in France last summer your mother was swimming in the sea: 'La mère nages dans (swims in) la mer.' Thus, by elaborating upon the relationship between two knowledge elements with the help of existing knowledge, stable facts will emerge in memory that are quite resistant to forgetting. Another example. The same applies to understanding and remembering the relationship between 'movement' and 'force' in physics. Many people believe that if an object moves it must contain a force that propels it forward, much like a driving car that moves over a highway thanks to its running engine. If there is no force (no 'engine'), the object will not move. Newtonian physics, however, assumes that once set into motion, an object needs no force to move on forever as long as there is no countervailing force such as gravity or friction. What helps in understanding this, is imagining that stopping the engine of a moving car does not stop the car. Despite the absence of a propelling force, the car continues to move forward, until road friction or brakes stop it. So, by elaborating on the relationship between force and movement through the example of the driving car, your memory constructs knowledge structures that turn out to be quite resistant to forgetting. Knowledge acquired this way has been demonstrated to be better usable.

*Learning in context*. A third element of learning is that people learn better in a meaningful context. Knowledge remains abstract as long as you only talk about ‘movement,’ ‘force,’ and ‘inclined planes.’ But as soon as a concrete context is invoked, such as a car driving on a highway, learning is facilitated. It is generally believed that learning in the context of situations relevant to the application of what is to be learned encourages the *transfer* of knowledge: Knowledge can be more easily applied. In medical education for instance, learning of medical knowledge is fostered if it can be done through confrontation with real (or simulated) patients.

*Intrinsic motivation*. A fourth element important to learning is intrinsic motivation. (Motivation is the *will* to learn.) Psychologists assume that there are two main forms of motivation: motivation driven by (1) extrinsic factors and (2) intrinsic motivation. If you are extrinsically motivated to learn, you are not that interested in the subject to be studied, but study in the first place because you expect a *reward*, for instance a ‘pass’ on your exam, or a high salary when you’ve graduated. You are intrinsically motivated if you study because the topic at hand does interest you in itself. For instance, you would read this particular book anyway, even if no examination followed.

Proponents of problem-based learning suggest that acquiring knowledge through working on problems in small groups will foster learning, because such an approach enables the processes mentioned here. (1) The initial discussion of a problem helps in activating relevant prior knowledge, thus facilitating the comprehension of subsequently studied new information on the problem. Problem discussion would therefore add to the construction of knowledge. (2) Discussing a problem and discussing the subject matter acquired through self-directed learning is known to be a good way of elaborating on a particular topic that leads to the establishment of knowledge structures in the mind that are more resistant to forgetting and thus more usable. (3) The situation of a problem is the context in which new learning takes place and (4) problem-based learning has been shown to increase intrinsic motivation.

## 1.3 Learning from and with each other

Problem-based learning means that although much of the work has to be done on your own, you will also be working with other students. It both recognises and highlights the interactive or collaborative aspects of learning. In your tutorial group, fellow students can make additional information resources available, come up with new ideas for explaining the problem-at-hand, and suggest alternative resources, which you might have overlooked on your own.
You can learn a great deal from your peers, not least because of the mixed nature of the group, which will vary according to age, gender, experience and interpersonal skills. This does not necessarily mean that students will always agree with each other. Discussions will arise occasionally in which issues will be hotly contested. Different interpretations of the same information may emerge and different theories of the same phenomena will lead to healthy competition in the tutorial group. These differences of opinion regarding the subject matter actually aid learning. By expressing personal opinions, through arguing, through asking questions, and through

the confrontation with someone else's ideas, students are actively involved in the subject and are likely to enrich their knowledge. Where differences in personal and social ideas occur and are discussed in the context of instruction, it becomes possible to shed light on an individual student's perspective by comparing it with alternative standpoints. Productive conflict involves the critical evaluation of ideas, as opposed to dysfunctional conflict, in which members try to do whatever it takes to get their own way. Learning from and with each other in a tutorial group assumes a willingness of all those taking part to work actively together. The success of a tutorial can only be achieved if every member of the group is prepared to contribute something towards it. Tutorials where students merely attend for their own personal gain are unlikely to prosper. Tolerance of the views of others by participants is another important facet of the tutorial.

It is also important for the tutorial to follow certain working procedures. These procedures will be dealt with in greater detail in subsequent chapters.

## 1.4 What do we know about the effectiveness of problem-based learning?[2]

Often, students are exposed to educational technologies that have never been scientifically studied. For instance, lecturing, certainly the most used mode of teaching in higher education, has hardly ever been studied, and not much is presently known about its effectiveness. Since problem-based learning is a fairly new approach to learning and instruction, its proponents have faced scepticism and rejection by those favouring more conventional methods of teaching. The scepticism of these opponents has encouraged much research. Let's briefly summarise what we know about the effects of problem-based learning. The findings displayed first are all based on comparisons between problem-based and conventional curricula.

First, students in problem-based curricula enjoy their education far more than students in similar conventional curricula; they think their training is more relevant to their future professional life; they prefer working in small groups more than attending lectures, they report less stress, fewer feelings of being powerless, and less fatalism, and feel more supported by their learning environment.[3]

Second, in Dutch national surveys comparing the quality of higher education, problem-based curricula always end up first or second in their category.[4] Third, graduates from problem-based schools report that they consider themselves better equipped in interpersonal competencies, such as teamwork, consulting with clients, and leadership. In addition, they consider themselves more independent, more creative and more efficient in their work.[5] And fourth, they display better problem-solving skills than students from conventional programs,[6] although they do not have more profession-specific knowledge.[7]

The second source of our knowledge about PBL comes from experiments. A representative study was conducted by De Grave, Schmidt, and Boshuizen.[8]

They presented groups of medical students with a problem about blood circulation. The students in the 'experimental' groups first discussed this problem and subsequently studied a problem-relevant physiology text. The other 'control' groups of students discussed an irrelevant problem (about perception) and then studied the same text as the experimental groups. The knowledge acquired from the text was tested in both sets of groups. The set who had discussed a relevant problem prior to studying the text gained a much higher test score, indicating that they had learned more from the same text.

In summary, research findings suggest that problem-based learning facilitates learning, makes learning more interesting, and provides a learning environment that is more student-friendly. In addition, problem-based learning fosters the development of profession-relevant competencies in graduates. These are all good reasons to give problem-based learning a serious try.

## 1.5 Problem-based learning in an electronic environment

Electronic work stations are increasingly being used in support of educational processes. In its simplest form students are offered e-mail facilities and the learning materials are presented on the internet. More advanced systems support the work of students outside the tutorial group by offering options to post findings and to comment on findings offered by others using social media. And obviously sophisticated tools like lab simulations, video presentations and graphic tools can be linked to text materials. Electronic learning environments provide good opportunities to make a clear end product, such as a concluding short report, with links to underpinning electronic notes and other documentation. To work effectively you have to fully explore the possibilities of the system in use. It's important to regularly check your deadlines for the work to be done in order to contribute well to the group result. Learning how to use an electronic work environment is also a good preparation for your professional career since similar systems are used to coordinate work processes in many fields.

## 1.6 Skills in problem-based learning

Now let's look briefly at the skills necessary for students to get the most out of problem-based learning.

It is important to recognise the major differences between secondary and higher education. The latter distinguishes itself from the former in the following areas:
- the amount of subject matter to be mastered is more extensive;
- the material is usually more demanding;
- teachers check less frequently if the student has grasped the subject matter;
- students are more often left to work on their own initiative;

- the subject matter may be presented in another language (in countries where English is not the first language).

When the concept of problem-based learning is introduced, the following points also apply:

- the subject matter is often not dealt with on a subject-by-subject or book-bybook basis, but is provided in the form of problems of a multidisciplinary or integrated nature;
- greater demands are placed on students to work on their own initiative. They are expected to analyse problems for themselves, set their own learning goals and search the literature for themselves;
- students must be able to work together in small group tutorials.

This book deals with three types of skills that are essential to the concept of problem-based learning:

1 skills necessary to deal with problems in a methodological manner;
2 skills necessary to conduct individual learning activities;
3 skills necessary to function successfully in small groups.

Chapter 2 focuses on the process of problem-based learning in detail, elucidating the strategies that can be used when working on a range of different types of problems. Chapter 3 concentrates on working in the tutorial as well as discussing communication within the group and the different roles played out in the tutorial. It pays particular attention to the respective roles of the chair (the leader of the discussion), the scribe and the tutor. Chapter 4 looks at individual study skills with the emphasis on study activities essential to problem-based learning e.g. identifying sources of literature, studying these, and setting up a documentation system. Chapter 5 discusses the skills that need to be mastered in order to function well within the tutorial group, including aspects such as the exchange of information, listening and summarising skills and evaluating tutorial group meetings. Chapter 6 focuses on the responsibilities of the group's chair during the phases of both analysis and synthesis as well as on improving collaboration between the members of a tutorial group.

Chapters 5 and 6 also offer appendices presenting various observation schemes and questionnaires useful for self-reflection and feedback from peers as well as tutors.