Readers may wonder why there is another book on problem-based learning (PBL). Let us give the reasons how this book came about.

Many tutors are experiencing problems with their students. The students are not learning what they should and many have no idea how to learn. Students find problem solving, critical thinking and self-directed learning difficult. In order to overcome this problem, many tutors have been turning to problem-based learning as a means of teaching their students in their respective disciplines. We have been implementing PBL since 1996 as a means to help students to learn better. Our experiences with PBL have been very positive and encouraging. Students have benefited enormously from the study.

Since then, we have been very keen to promote PBL as a powerful way for students to learn problem-solving, critical thinking and self-directed learning skills in workshops for colleges teaching computer science and engineering subjects. Those who came to the workshops were very encouraged by what we shared with them about our experiences with PBL for our students. Many wanted to learn more about PBL and told us that they could not find any books that actually helped them to start. Most of the books are written for the medical profession, but none of them are really ideal for someone who is new to PBL. As far as we know, there is no book written about PBL for technology teaching. Those who have read the PBL books told us that many of the books talk about what PBL is and the benefits of it, but there is little information about how to conduct PBL. Our colleagues then urged us to write a book that would help them to learn about PBL and how best to conduct it. This book is the outcome of that challenge.
PBL occurs in any environment in which the problems drive the learning. Many educators in higher education and schools are contemplating incorporating PBL in their curriculum. However, to achieve its full potential, PBL needs to be well designed and the tutors employing the method need intensive preparation through hands-on educational experiences. This book is designed to help anyone who wants to learn how to implement PBL and understand the different phases of how PBL is conducted. It also prepares staff to consider the implications of moving to PBL and assists in preparing for the practicalities of the introduction of PBL into the curriculum.

The chapters focus on the following areas:

- Chapter I: Traditional versus cognitive learning
- Chapter II: What is problem-based learning?
- Chapter III: Why PBL?
- Chapter IV: Role of the tutor
- Chapter V: Preparing students for PBL
- Chapter VI: Developing problems /triggers
- Chapter VII: The PBL tutorial process
- Chapter VIII: Assessment
- Chapter IX: Integrating e-learning technology
- Chapter X: Curriculum and organisational issues
- Chapter XI: Lessons learned and tips
- Chapter XII: Postscript

The first three chapters of the book explain the rationale for problem-based learning, define PBL, and explain why there is growing interest and how it is aligned with current thinking about learning in higher education.

These chapters underpin the practice of PBL. The book then proceeds to explain the practical details of implementation, with examples and checklists which are intended to help readers deal with important issues. Problem-based learning is a fundamental shift away from a traditional teacher-led model of education, and this has considerable impact on all aspects of teaching, learning and assessment. Chapters IV through VIII discuss these points in detail. Chapter IX examines the variety of ways in which e-learning technology can be used to support PBL e-learning is currently the focus of much attention, and it is by no means obvious that PBL and e-learning are closely aligned. Finally, after examining the details, we turn to the wider issues of curriculum design in Chapter X.

There are some advocates for a curriculum that is 100% PBL, yet some institutions introduce it into single course modules. Is there a best way? In Chapter
XI we reflect on our PBL experiences and share some of the insights we have learned. We also provide some useful guidelines to some of the issues discussed. Each of the chapters is now briefly reviewed.

Chapter I: Traditional vs. Cognitive Learning

Traditional teaching is generally known as didactic instruction in which information is presented to students by the tutor in a class. The teacher is the sole information-giver, undertaking lectures to a large group of students. The students sit passively to receive the information from the tutor. Very often there is little interaction between tutor and students. Classes are typically driven by teacher talk—or as information giver—and depend heavily on textbooks for the structure of the course. It is generally accepted that there is a subject content that the students must come to know. Information is often divided into discrete parts and builds into a whole concept. The tutor’s objective is to transmit their thoughts and meanings to passive students.

Learning by students is often detached from real world cases. This is because knowledge is often taught as context-independent. Students find it very difficult to transfer what they have learned to solve problems in the real world. They tend to memorise content without understanding the concepts learned and knowledge of how to apply it to actual problems. How can we make the need and reason to learn content apparent? How can we help students actually apply the information they learn?

Although there is no consensus among educators on how learning occurs, we believe that it is important to have a look at learning—what it is, how it occurs, and the different types of learning—before addressing these issues. This chapter looks at learning in general and the three main learning theories: behavioural, cognitive, and constructivist learning. Behavioural learning is described as a change in the observable behaviour of a learner, made as a function of events in the environment. Learning in behaviourism is equated with changes in either the form or frequency of observable performance.

Cognitive learning is equated with discrete changes between states of knowledge rather than with changes in the probability of response. In cognitive learning, the issues of how information is received, organised, stored, and retrieved by the mind are important. Learning is concerned not so much with what learners do, but with what they know and how they came to acquire that knowledge. The most dominant of the cognitive learning theories is based on an information-processing approach. Cognitive learning theories have been challenged by the currently popular constructivist learning. The philosophical assumptions for
both behavioural and cognitive theories are primarily objectivistic. The objectivist philosophy, or world view, holds that there is an objective world that we perceive more or less accurately through our senses. Knowledge in objectivist learning is thought to exist independently of the learners. Learning consists of transferring that knowledge from outside to within the learner. Constructivist learning theory on the other hand is based on the assumption that knowledge is constructed by learners as they attempt to make sense of their experiences. Learners actively construct knowledge based on prior experiences, and they are not empty vessels waiting to be filled.

There are several approaches advocated by researchers that have been shown to be effective in promoting constructivist learning. These include cognitive apprenticeship (Collins et al., 1989), cognitive flexibility theory (Spiro et al., 1991), anchored instruction (CTGV, 1991) and problem-based learning (Barrows, 1992).

Chapter II:  
What is Problem-Based Learning?

A search on the educational databases will confirm the rapid and extensive proliferation of PBL as an instructional method in many different disciplines. So, what is problem-based learning? Problem-based learning (PBL) is an instructional approach borrowed from the medical field. In PBL, students working in groups take on the responsibility of solving a professional problem. The underlying assumptions in traditional learning contrast sharply with those in PBL. The traditional approach views teaching as transmission of knowledge and learning as acquisition of that knowledge. In the traditional approach, it is generally assumed that knowledge is learned most effectively when it is organised around the disciplines and taught through lectures. In PBL, learning involves both knowing and doing. Knowledge and the use of that knowledge are both important. Students bring prior knowledge to their learning in PBL. The problem is used as the stimulus for learning. Problems are typically messy, ill-defined, and representative of the problems that students will face in real life. In PBL, students are assigned to groups that are responsible for framing the problem and deciding how to use the knowledge found to solve the problem. Each group usually has five or six members. The problem challenges students to learn-to-learn, working collaboratively in groups to seek solutions. It also engages students to initiate learning the subject content. PBL requires students to find and use appropriate resources and prepares them to think critically and analytically. The aims of implementing PBL are: to integrate knowledge and skills from a range of multidisciplinary modules; to teach students how to work as a team; and to develop problem solving, critical thinking, and learning-to-learn skills.
Chapter III: Why Problem-Based Learning?

There is much literature written in support of the assertion that, relative to conventional lecture-based curriculum, PBL offers several benefits to students. Its curricula improves student problem-solving skills and enhances understanding and retention of concepts learned as well as the development of critical thinking skills. PBL makes students more motivated and engaged in their learning. It offers students a reason they are learning the materials that they are currently working on. This is because students can see that the problem they are working on is based on a real life problem. Students in PBL develop high-order thinking skills that enable them to know why they are getting the right answers to the problem. PBL also promotes metacognition and self-regulated learning by asking students to generate their own strategies for problem definition, information gathering, data-analysis, and hypothesis-building and testing, comparing these strategies against and sharing them with other students’ and mentors’ strategies.

Students in PBL appear to enjoy learning and are more actively involved in their own learning. Reports on the benefits of PBL on students’ performance on national examinations vary greatly. Some showed that no harm was done when moving to a PBL curriculum to reports of improved performance for students in PBL curricula. Our personal experiences using PBL have been very positive, showing students in general benefited from PBL and they also enjoyed doing so.

Chapter IV: The Tutor’s Role

Traditional lecture-based learning is tutor directed. It is generally acknowledged by tutors that knowledge consists of facts that need to be disseminated to students because students have a deficit. The tutor’s role is simply the transmission of knowledge to the students. Tutors in a problem-based learning curriculum need to alter their traditional teaching methods of lectures, discussions, and asking students to memorise materials for tests. Problem-based learning begins with the introduction of an ill-structured problem on which all learning centres. The tutor assumes the role of coach or facilitator rather than knowledge-holder and disseminator. Instead of a disseminator of knowledge to students, tutors are co-learners with the students. They monitor the learning by probing and challenging students’ thinking. Tutors focus their attention on questioning student logic and beliefs, providing hints to correct erroneous student reasoning,
providing resources for student research, and keeping students on task. Another important role of the tutor is to manage group dynamics of the students making sure that the tutorial process keeps moving. As the students become more proficient, the tutor’s role gradually fades away.

Chapter V: Preparing Students for PBL

Students in PBL assume the role of active problem-solvers, decision-makers, and meaning-makers, rather than passive listeners. They are given an ill-structured problem that mirrors real-world problems. The problem is messy and complex in nature. In PBL, students simultaneously develop problem solving strategies, disciplinary knowledge bases, and critical-thinking skills. Students in PBL are required to inquire, gather information, and reflect on the solution. They are active participants and engage in the learning process by constructing meaning. In problem-based learning, students assume increasing responsibility for their learning, giving them more motivation and more feelings of accomplishment, setting the pattern for them to become successful life-long learners. PBL requires students to take on active learning strategies and adopt self-directed learning dispositions. Some students find it difficult to cope when asked to transform into active critical thinkers.

Students who are new to a PBL classroom environment may find it, initially, very difficult. This is because they have been asked to take responsibility for their own learning, to work on ill-structured problems where there is not a pre-established right answer and where they are expected to structure their own approach to acquiring and using information to solve problems. Group work is an integral part of PBL. Students need to learn how to make optimal use of their time and resources, while working in groups. Working effectively in groups involves knowing how to organise the work, distribute responsibility, break up complex tasks, and provide useful feedback on work that is done. Students must learn how to work in groups.

When faced with a problem, students often find it difficult to identify the critical issues and to generate a coherent solution. Students are often unclear about how they can relate what they are currently reading to what they already know. They are also unfamiliar with different stages of the problem solving process, such as generating hypotheses, providing logical arguments, and transforming data into a product.

Helping students to enter this new type of learning environment requires that students are prepared for it. It is important for students to understand what they are getting themselves into. This chapter describes how to prepare students to accept risk and uncertainty and to become self-directed learners.
Chapter VI: Developing Problem Statements/Triggers

In many ways, the problem statement, or trigger, is the key to successful PBL. If it does not stimulate the students’ interest, or enable students to generate learning issues that relate closely to the desired learning outcomes, then there are likely to be difficulties with both team work and achieving cognitive learning outcomes. It also needs to ensure students cannot simply adopt a “divide and conquer” approach, since this often means students do not integrate their knowledge or elaborate on their findings.

In this chapter, we explore the issues around the development of problem statements and collect advice from a variety of experienced practitioners on what makes an effective problem statement as well as what to avoid. We will also describe a possible process for the development of problem statements (triggers) and discuss examples. The chapter concludes with a number of examples from computing, management, and psychology to illustrate how triggers can be constructed and analysed.

Chapter VII: The Tutorial Process

The tutorial process is the hub of all learning in PBL. During the tutorial session, which typically lasts an hour, the teaching role of the tutor becomes one of questioning, probing, encouraging, critical appraisal, balancing emphasis, promoting interaction, and prompting students to become aware of the reasoning skills they are using. As the group works through the problem, students’ progress is monitored by the tutor, and feedback is delivered along with identified research topics for the group. As the process progresses, ideas are challenged by other group members or by the teacher, if necessary. The process is cyclical, and it is repeated several times as new information is learned and ideas have been modified to generate new learning needs. Solving the problem is not the most important objective; the power of PBL is found within the learning process itself through student-directed inquiry. Facts and concepts are not taught directly, but integrated within the learning process. The tutorial process consists of several steps. The problem is presented and read by group members. A member of the group acts as scribe to write down facts as identified by group. Students discuss what is known (the facts). They brainstorm their ideas and formulate their hypotheses. Students then identify what they need to learn in order to prove or disprove their ideas. Students share research findings with their peers. The steps are repeated until the problem is solved. During the
tutorial process, the tutor uses open-ended questions to foster student metacognitive growth. If necessary, ask questions like: What is going on here?; What do we need to know more about?; What is your evidence?; and Can you tell me more about it? As students participate in PBL over time, they become self-directed learners who are able to ask their own questions and identify what they need to know to continue their learning.

Chapter VIII: Assessment

Assessment probably has a more important effect on student learning than anything else. For the student, high grades and good qualifications signify success and open better opportunities in life. This chapter critically examines the issues for assessment in problem-based learning. Traditional examinations and coursework are not aligned well with the PBL approach and can undermine student learning if not adapted carefully. This chapter first considers the reasons why we should assess and then discusses the place of formative and summative assessment. We proceed to discuss what should be assessed. In particular, we argue that it is essential to assess the process skills involved in PBL in addition to subject knowledge and skills, since this adds credibility to our claim that they are important. Having determined what to assess, the next fundamental question is how we should assess and what techniques and assessment criteria we can use that are particularly relevant to PBL. A particularly thorny issue is the balance of team and individual assessment. Finally, we consider the timing of assessment and raise the issues of who should assess. Should students take part in assessing each other and themselves?

Chapter IX: Integrating E-Learning Technology

Information technology has been used in teaching, learning, and assessment for many years, from programmed learning and on-line tutorials, which are teaching-centred at one end of the spectrum, to computer-supported collaborative environments, which are learning-centred. The term e-learning has developed over recent years to subsume these and related terms.
In this chapter, we will focus on the pedagogy and identify relevant aspects of e-learning technology that we believe are particularly relevant to problem-based learning. The chapter commences by discussing a model from Ron Oliver, identifying three essential components: learning tasks, learning resources, and learning supports. We then move on to focus on PBL specifically, adapting a framework from Ronteltap and Eurelings and using this model as the structure to analyse the use of e-learning technologies to support PBL. These include information related activities such as providing resources for faculty and students, structuring the PBL case, and the role of wireless networking. The second aspect of this model concerns communication-related activities, and we discuss the development of asynchronous and synchronous communication tools, such as virtual learning environments, wikis, video-conferencing, intelligent learning companions, and their role in the PBL case. The final sections discuss the blended learning approach and how e-learning technologies can support assessment activities in PBL.

**Chapter X: Curriculum and Organisational Issues**

The subject of problem-based learning can raise some surprisingly strong emotions, both in terms of the right process to use and the right curriculum model. For example, on the PBL Initiative Web site (director, Howard Barrows), the minimum essentials for PBL are stated, and include: “*Problem-based learning should not occur within a single discipline or subject.*”

This requires a large scale intervention, obtaining commitment, collaboration, and consensus from staff in multiple subject areas, followed by much planning and training. It can be quite intimidating for a teacher who can see many benefits in the PBL approach and would like to try out PBL “in the small.”

While there are numerous benefits from implementing PBL throughout a curriculum, which are discussed in this chapter, there is an alternative view of PBL as a pedagogical approach. It can be applied at several levels, from a single session to a fully integrated curriculum.

In this chapter, we explore some of the curriculum and organisational issues of implementing PBL, both “in the small,” that is at module level, and “in the large,” throughout the curriculum. The chapter discusses student preparation, issues of team size, facilitation models, classroom facilities, and how PBL can be introduced within an otherwise traditional lecture-based model. The later section of the chapter analyses the benefits and requirements for introducing PBL throughout the curriculum and describes a model for systematically developing the framework.
Chapter XI: Lessons Learned and Tips

Many books and articles have been written about tutors’ experiences of PBL in various subjects. Our experiences may have many features similar to others. We have enjoyed implementing PBL to help our students to learn better in Computing Science teaching. Although we have been very pleased with the outcomes of our PBL experiences, it was by no means easy to start with. Since 1996, we have been learning and researching how we can improve our PBL process to help students to cope with the change of mindset they needed to better cope with PBL. This chapter is an attempt to show some of the insights we have learned.

Chapter XII: Postscript

The final chapter is presented as a postscript, a collection of advice from experienced practitioners. Since learning is complex, institutional contexts differ widely, and PBL changes many aspects of the learning system. We posed the following question to a wide range of PBL researchers and practitioners: “What is the most important advice you could give someone just starting to use PBL?”

The responses identified three themes: preparation and planning, the inevitability of criticism and difficulties, and the importance of adaptation to local context.

We trust that this book will contribute to the advancement of PBL and generate interest to promote learning among students so that they might become better learners.

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