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Learning Recursively: Integrating PBL as an Authentic Problem Experience

Peter R. Albion

Faculty of Education, University of Southern Queensland, Australia

Abstract

Problem based learning (PBL) is widely recognised as a desirable approach to education of future professionals. One strong basis for its appeal is the use of authentic problems of practice, which make the relevance of what is being learned apparent to the learners and encourage development of attitudes and skills that will be central to continuing professional growth beyond graduation. However, the change from traditional lecture-based courses to PBL presents challenges to educators and the institutions in which they work. In many respects, the implementation of PBL can be itself an experience in PBL for the educator. This presentation will address some of the challenges associated with integrating PBL in a university setting from the perspective of those who design and teach courses using PBL, which will be understood as a spectrum of practices rather than a single approach that must be replicated in every instance.

Keywords: problem based learning; 21st century learning

1. The world we live in

The world has changed and is continuing to change at an increasing pace. If there was ever a time when the education acquired in the first twenty or so years of life could be expected to suffice for a working lifetime, this is not it. New information is being produced at such a rate that we all need to continue learning throughout life.

The significant changes in our world have been described in different ways. Friedman [1] characterised the globalised world of the twenty-first century in terms of 'flattening' and described ten forces responsible for the flattening. Among those forces Internet connectivity, access to information using search engines, and mobile communications were keys to removing barriers to goods and services being provided across the world, leading to the 'flattening' of the economic world. In the new 'flat' world, Friedman argues that education must be about learning how to learn, how to navigate information, and how to bring curiosity, passion and creativity together to synthesise solutions to problems that are frequently cross-disciplinary. Conrad [2] recalled that in 2005 Daniel Pink "identified abundance, Asia, and automation as the three factors driving a societal evolution from and information base to a conceptual base" (p. 157) in which design, story, symphony (synthesis), empathy, play, and meaning play increasing roles in achieving success. More recently, Hagel, Brown and Davison [3] have characterised the change in the world as being from 'push' to 'pull', from approaches that attempt to forecast needs and design systems to meet them to approaches in which individuals access flows of information and harness them by attracting others to achieve goals.

Common themes emerge across these views of our changing world. Increased opportunities for individuals to make a difference and connectivity at both local and global levels are evident. However, the most notable change relates to the availability of information and how we access it. Each of these themes holds implications for education.

Prior to the popularisation of the World Wide Web (WWW) from about 1995 most people lived in a world where information was relatively scarce. When a student was set an assignment the core challenge was usually to locate the relevant information, which could then be used as the basis for writing a response. Most often that information was contained in one or more books held in a library where just one person could access them at a time. Locating the appropriate books was a matter of searching a catalogue using whatever keywords seemed appropriate. This approach to dealing with information is characteristic of an understanding of information as being in 'stocks' such as books that are comparatively static [3].

Now we live in a world where information is abundant and changing so that it should be regarded as 'flows' rather than 'stocks' [3]. The new challenge for students when they are set an assignment is to

select and process the most relevant information from the large amounts that are usually available. Most of that information, especially the most current, is available through the WWW, which can be accessed from almost anywhere without affecting its availability to others. Searching can be easily done across the full text of the documents rather than on a limited set of keywords.

In an age of information scarcity it was reasonable, and often necessary, for a teacher to act as a dispenser of knowledge through lectures and other teacher-led activities. Important attributes of the teacher were breadth and depth of knowledge in the relevant field and ability to convey that knowledge to learners. In an age of information abundance, learners can access information for themselves and it is no longer necessary for the teacher to act as a conduit. Rather than dispensing knowledge, the teacher is now required to guide students in their selection and use of information to build their own knowledge.

These changed views about how education should deal with information are often linked together with related ideas in a broad area of educational conversation around what are described as 21st Century Skills. These are the skills that those promoting this agenda argue will be needed by graduates of our education systems if they are to succeed in the changed world in which we will be living through the next several decades. In broad terms the desirable outcomes of 21st century education are in the areas of core subjects interwoven with themes such as global awareness and citizenship; learning and innovation skills; information, media and technology skills; and life and career skills [4].

The need for these new approaches to education arises because today's students are likely to have multiple careers and will need to learn new skills throughout their lives. They will need to work collaboratively in teams that deal with constantly changing flows of information across multiple disciplines. With the world changing so rapidly there is now less importance attached to "learning about" the world as it is and more to "learning to be" in the world as it emerges [5]. Learning of this kind is more likely to be achieved by approaches that engage students in doing rather than listening [6] using authentic learning in modes that may resemble apprenticeship [5].

2. Why Problem Based Learning?

This prescription for 21st century learning will seem familiar to those experienced with Problem Based Learning (PBL). The focus on learning to be a professional by engaging in activities related as closely as possible to authentic professional practice is at the heart of PBL for essentially similar reasons to those offered for embracing 21st century learning as the way forward for education.

PBL began with medical education at McMaster University in the 1960s [7] as a response to concerns that education focused on academic disciplines might not be the most effective means to prepare future professionals to integrate knowledge across disciplines [8]. Since that time, PBL has been adopted in many countries and in different fields of professional education, including nursing, engineering, law and business [9].

Reasons for adopting PBL in its original implementation included students' perceptions that some knowledge they were required to acquire in traditional medical education was irrelevant, lack of integration of subject matter from different disciplines, the need for students to be oriented toward continuing professional education beyond graduation, and the desire to graduate students read to apply their knowledge appropriately in professional practice [10]. PBL addressed four objectives that were often not addressed by other educational approaches. These were structuring knowledge to support practice, developing effective clinical reasoning, developing self-directed learning skills, and increasing motivation for learning [11].

In comparison to more traditional instruction, PBL has been shown to be more nurturing for students and more enjoyable for students and teachers. Moreover, on clinical examinations PBL graduates perform at least as well as conventionally prepared students although they may be less well prepared on basic sciences [12]. Another study, of students studying nursing through PBL, reported significant changes in perceptions of the importance of self-directed learning and of personal ability to engage in it [13].

PBL emerged as an educational approach long before the current information revolution that has resulted from the widespread availability of the Internet. It was developed for the education of 20th century professionals, without consideration of the need for 21st century professionals to deal with the increasing volume of information that is available effectively instantaneously anywhere that has Internet access. Although almost ubiquitous availability of information may make it less necessary to commit large amounts of information to memory, the challenges associated with locating, selecting and interpreting information in professional contexts have probably increased rather than decreased as a consequence of more information being available. PBL remains as relevant as ever as an approach to developing the attitudes and skills required by professionals in any sphere.

Twenty-first century professionals must be information literate, able to determine their information needs, locate, evaluate and apply information as required. They must also be adaptable, capable of learning as necessary and bringing together knowledge from multiple disciplines to solve new problems. PBL seems ideally suited to the development of such capabilities.

3. Implementing PBL – an instance of PBL

According to Boud [8], a PBL experience begins with presentation of a problem representative of the problems encountered in the relevant profession. Students work in small groups to analyse the problem and determine what information would be required for a solution and then undertake individual study and research to obtain the necessary information. When they return to the group they share their findings and apply them to develop a solution to the original problem. Finally the group reflects on the process, summarizing what they have learned and integrating it with their prior knowledge.

For educators seeking to adopt PBL in their own courses the process of implementation can be considered as an instance of PBL. It begins with a problem of professional practice, namely, how to design and implement a course that achieves the relevant objectives using PBL as the learning approach. To accomplish that will require knowledge of PBL, how it works and the challenges that might be encountered. Equipped with this knowledge it should be possible to design a course using PBL and test the solution. Reflection on that process will then inform refinement of the course in subsequent implementations.

The cycle implied in this process is recognisable as a variation on widely used problem solving heuristics such as "understand, plan, execute, evaluate" or "ask, imagine, plan, create, improve", which is currently being promoted as the engineering problem solving cycle through the Science Technology Engineering Mathematics (STEM) education movement in the USA [14]. Viewed in this light, the implementation of PBL can be seen as a recursive process in which recurrent cycles of PBL applied by the educators to their own practice will improve the PBL experience of successive classes of students. The may be no finally correct way of implementing PBL but the process is capable of informing its own evolution beginning with growth in our understanding of the nature of PBL.

4. What counts as PBL?

Across a variety of professional fields PBL appears to have five common characteristics as described by Bridges (pp. 5-6) [15]:

1. The starting point for learning is a problem (that is, a stimulus for which an individual lacks a ready response).
2. The problem is one that students are apt to face as future professionals.
3. The knowledge that students are expected to acquire during their professional training is organised around problems rather than the disciplines.
4. Students, individually and collectively, assume a major responsibility for their own instruction and learning.
5. Most of the learning occurs within the context of small groups rather than lectures.

PBL tutors "do not serve as dispensers of information. Rather, they serve as resources to the team and provide guidance and direction if the team solicits assistance or becomes bogged down" (p.7) [15]. Such a stance is clearly consistent with the requirements of 21st century learning.

Many advocates of PBL will argue that it is best implemented at a program level, with each course adopting the PBL process as just described, so that students experience their entire degree through PBL. In this view there would be clear distinctions between PBL and related approaches, such as anchored instruction, case-based learning and project based learning, that share common elements such as the use of authentic situations. There may be value in adopting such purist views of PBL but there are frequently challenges to the implementation of PBL that make it difficult to achieve such purity in practice.

The question then arises as to the extent to which the characteristics of PBL must be in evidence for a particular learning experience to count as PBL. Barrows [11], one of the originators of PBL, proposed a taxonomy of PBL methods that adopts a broad view, recognizing a spectrum of methods that may exhibit features of PBL and achieve the key objectives of PBL to a greater or lesser degree. The four key objectives of PBL identified by Barrows [11] were:

1. Structuring of knowledge for use in clinical contexts (SCC),
2. Developing of an effective clinical reasoning process (CRP),
3. Development of effective self-directed learning skills (SDL), and
4. Increased motivation for learning (MOT).

Barrows considered two dimensions in the design of PBL, the presentation of the problem and the degree to which learning is directed by teacher or student. On the first dimension, a problem can be provided as a complete simulation of a real world problem in which students have to "assemble the facts through free inquiry" (p. 482). Alternatively it can be presented as a complete case with an organized summary of the relevant facts or somewhere in between. Arrangements in the class can be teacher-centred with the teacher directing activity, student-centred with the student taking responsibility for learning, or somewhere between.

Using these dimensions, Barrow described six PBL methods with varying strengths in achieving the four objectives using comparative values on an arbitrary scale as shown in Table 1. Lecture-based cases and case-based lectures are teacher-centred approaches, case method is mixed, and the remaining varieties are essentially student-centred. The first three methods using cases provide reasonably

complete information and the modified method provides partial information. Only the problem-based methods provide a full problem simulation requiring free inquiry by the students.

Table 1. Relative strengths of PBL varieties for achieving objectives (after [11])

	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

It is clear from Table 1 that the greatest advantages in achieving the objectives are delivered by the methods that most fully implement PBL using student-centred approaches based on full problem simulations that provide limited, if any, scaffolding and offer the most authentic experience. However, there are more limited benefits to be gained from the other methods, which may be more achievable in many circumstances than full PBL and may be used as steps more complete PBL as the challenges of implementation are met.

5. Challenges of PBL implementation

PBL is a significant departure from traditional instruction methods in the way that it uses problems to initiate self-directed learning and promotes collaborative learning. According to Hung, Jonassen, and Liu [16], these features impact on the dynamics among all participants, staff and students and present challenges for those implementing PBL. They discuss the implementation of PBL, and the associated challenges, under a series of headings that provide a basis for structuring this discussion.

5.1. Student and tutor roles

Students and tutors alike find the transition to PBL challenging, often because of varying interpretations of what is intended by self-directed learning [16]. Many students probably experience any class as a form of PBL in which their principal problem is understand the rules sufficiently well to construct whatever performance is required to succeed in the class. Shifting from more traditional approaches to PBL induces discomfort related to uncertainty about coverage of essential content and grades under the new system. Their discomfort typically decreases over time but the adjustment beyond previously learned roles takes as much as six months.

Tutors are also prone to feel initial discomfort around changed role expectations as they are expected to facilitate development of student thinking and independence as learners rather than provide content through lectures. The change will be particularly difficult for those who are accustomed to directing activities in class or see the primary role of the teacher as being to dispense knowledge. Tutors may have to learn new ways to communicate with students who have been found to attach importance to the role of tutors as metacognitive guides for developing their thinking.

5.2. Collaborative group work

Collaborative group work in PBL has benefits for learning, even for students who do not participate by speaking in group discussions [17]. However, students are typically accustomed to learning individually rather than in groups and may experience difficulty in making the adjustment to group work. The effectiveness of PBL groups may be affected by the group skills that students bring and their abilities to develop and maintain appropriate relationships among members. Group size has an effect and medium sized groups (six students) have been found to function better than larger groups (nine students) [16]. Larger classes therefore become problematic because of the need for sufficient staffing resource to provide for tutors to work with small groups.

Tutors may also find the adjustment to working with small groups difficult and will need to develop skills to facilitate group processes for students as well as adapting their own behaviours to providing guidance to students rather than lectures. Mixed results have been reported from research on the effect of tutor expertise in the subject. In general there appears to be little difference in effectiveness and subject experts sometimes tend to lecture more rather than facilitate PBL self-directed learning among the students [16].

5.3. Design of curriculum and assessment

Hung, Jonassen, and Liu [16] discuss PBL curriculum design at length, beginning by emphasising the central importance of the collection of problems in any PBL curriculum. A set of problems must be selected or designed so that they collectively ensure that learners engage with the knowledge considered to be important. The problems must then be presented in ways that stimulate learners to begin appropriate research and go on to develop solutions.

Because the goals of PBL courses are focused on understanding, application and transfer of knowledge rather than on acquisition of factual knowledge, conventional examinations that assess factual knowledge are less appropriate for students from PBL classes. This incompatibility may account for some instances in which PBL students learning outcomes have been mixed. Research reports indicate that PBL students perform better on assessments that require application and clinical reasoning compared

to traditional students who fare better on basic knowledge [16]. It is important to develop assessments that provide valid indicators of achievement for PBL students.

5.4. Use of Technology in PBL

Multimedia products, including emerging 3D virtual worlds like Second Life™, have been used to construct environments for PBL [18, 19]. Most often multimedia content has been used to provide a more authentic presentation of the problem used as a PBL stimulus but as technology advances more comprehensive environments for PBL are being developed. Research has found no significant difference gains for such environments in respect to factual knowledge acquisition or problem solving skills but there have been higher levels of motivation reported [16].

PBL most commonly involves intensive discussions among small groups of students guided by tutors. However, new forms of computer-mediated communication (CMC) have encouraged development of online or distributed PBL. The simplest of these have used standard Internet tools such as email, discussion forums, text chat, and teleconferencing systems to enable interaction among small groups of students who may be widely scattered. Research has reported that the major advantages of online PBL are better access to and retrieval of information and that, possibly due to limitations of the technology, collaborative learning has so far shown little benefit [16].

6. Facing some challenges with PBL

Although the categorisation of challenges in the previous section is helpful for thinking about the various aspects of PBL that may present challenges, reality is often more complex and it is may be difficult to present examples as being uniquely related to one of the categories. More often an example or the evolution of a series of examples will involve multiple categories to a greater or lesser degree.

6.1. Offering PBL for distance education

The University of Southern Queensland (USQ) is a large provider of distance education to undergraduate and postgraduate students in Australia and elsewhere. About 75% of the students at USQ study at a distance. Traditionally, distance education was based on packages of printed materials sent to students with interaction restricted to exchange of assignments for feedback. In 1996 USQ offered its first completely online program and all courses now have access to facilities for providing online materials and engaging students in interaction through computer mediated communication. Care is taken to maintain equivalence of educational experience for different modes of offering. If PBL is to be offered to students studying on campus it is important to be able to offer it to students studying at a distance.

6.1.1. Interactive Multimedia-PBL (IMM-PBL)

IMM-PBL was developed from 1996 to 2000 at a time when convenient Internet access was not commonly available to USQ students. Design proceeded on the basis that, if multimedia materials could incorporate the essential qualities of PBL, then it should be possible to offer PBL experiences to independent learners who were isolated by distance or other circumstances. This approach contrasted with conventional PBL which makes extensive use of small group interactions supported by tutors and needed to address those characteristics of PBL in its design [18, 20].

Studies of student thinking during the initial phase of PBL [21] confirm that exposure to the different ideas of group members leads to conceptual change through encouraging activation and elaboration of existing knowledge and integration of alternative views. The IMM-PBL materials were designed to incorporate an activation task serving a similar purpose to the initial PBL group exploration of a problem. They also included a variety of different responses at appropriate stages in the problem solving process to stimulate cognitive dissonance similar to that produced by interaction among a group of learners. In these ways key affordances of group interactions in PBL were provided by a multimedia package.

The role of tutors in PBL groups is not to act as informants but to facilitate the group process by modelling higher order thinking and challenging the thinking of learners [8]. Equivalent support in IMM-PBL was offered through inclusion of heuristic aids [22] and breaking problems into sub-problems to provide scaffolding [23].

According to a review group of educators experienced with PBL, the IMM-PBL materials matched the characteristics of PBL other than group interaction. Teacher education students who trialled the materials responded favourably, perceived them as relevant, and reported learning that confirmed the value of the materials for independent learning in a mode comparable to more typical PBL [20]. In this instance the challenges of PBL at a distance were addressed by using knowledge of PBL to guide design of materials that offered students an experience of PBL.

6.1.2. Engineering problem solving

The widespread availability of the Internet has opened new opportunities for students studying at a distance to participate in group work that was not practicable using previous technologies, which were either too slow (post) or too inconvenient and expensive (telephone) for the frequent interchanges

needed for effective group work. The USQ engineering program includes courses in which students are required to work in teams to solve "open-ended contextual engineering problems" [24]. Those students studying on campus work in teams that are able to meet during class but distance students work in "virtual teams". The course is presented through the USQ Learning Management System (LMS), which is based on Moodle. Each team has access to LMS tools such as discussion forum and wiki but also use other technologies such as email and synchronous chat to exchange messages and files as they work to develop the required deliverable in the form of a report. On campus teams also use the LMS discussion forums to increase the flexibility with which members can interact.

Although there is no significant difference in the overall performance of virtual teams compared to on campus teams, the virtual team members do have to overcome additional barriers with respect to learning online. These have been categorised as related to Time, Technology, and Learning [24]. The issues around time relate to the interaction of motivation, priorities, and flexibility and their effects on team participation. Technology issues relate to student skills for handling the technology required to support their study at a distance. Learning issues are more complex and include personal learning styles or preferences and the interactions of those with other members of the team.

The staff responsible for the course plan to investigate the use of additional technologies, such as videoconferencing, to assist with formation of teams, and to develop additional strategies and materials to support team members to participate at levels that ensure teams function effectively. In this case the challenges of PBL at a distance are being addressed by a combination of course design and support for students.

6.1.3. Education inquiry course

In 2009 an undergraduate education course was taught for the first time to almost 400 students located across three physical campuses and an additional 320 enrolled online. The course was not described as using PBL but it adopted a *community of inquiry* approach [25] that shared some significant characteristics with PBL. At the core of the class activity was a series of cycles of collaborative inquiry in which small groups of about six students took some stimulus material as a starting point for research that was to culminate in a group response to a philosophical question triggered by the stimulus material.

For the students on campus, tutors working in the context of a larger tutorial class supported small groups. This allowed for some initial facilitation and occasional monitoring ensuring satisfactory group process and progress toward the goals. Students enrolled online presented more of a challenge for developing productive patterns of work within the virtual small groups that were established for them with private discussion forums and wiki areas. Some online students participated in virtual tutorials conducted in Wimba (http://www.wimba.com/), which supports voice and visuals for synchronous communication but most used only the asynchronous discussion forums provided in the LMS (Moodle). Results were mixed. Some online groups functioned effectively and produced final results comparable to those produced by on campus groups but others experienced difficulty with managing the computer-mediated communications effectively. In a small number of cases significant conflicts emerged, groups ceased to function effectively, and some rearrangements of group membership were necessary to allow students to complete the required activities.

The lessons learned from this experience with online collaborative groups are mostly around the need to prepare students for the experience of working collaboratively with other students in a virtual environment. The use of Wimba supported effective connections with those students who participated but the majority did not. For future offers additional efforts will be made to model appropriate patterns for interaction through Wimba and in asynchronous discussions.

6.2. PBL with large, distributed groups

Conventional PBL is designed to work with small groups of students who are able to meet in face-to-face sessions with tutors to offer guidance. Adapting PBL to large groups of students where there are insufficient tutors and/or where the students are geographically scattered presents particular challenges.

6.2.1. Managing a large problem through groups

An undergraduate education course designed to prepare primary teachers to teach technology was developed around the Australian national curriculum statement. It characterised technology education as being about "designing, making and appraising with materials, information and systems", which is similar to the engineering problem solving cycle, "ask, imagine, plan, create, improve", described above. Because most of the students had little or no prior experience of the "technology cycle" the course was designed to provide some of that experience as well as essential knowledge of the syllabus and associated pedagogy.

The final assessment task in the course was presented as a technology challenge, or problem, in which the whole cohort of students was to be responsible for developing curriculum materials and publishing them in a format that made them available to all members of the cohort. The task was one with practical benefit to the students who would be able to access and use the curriculum materials after graduation and they had strong motivation to succeed.

Although the curriculum design was not described to the students as PBL the open-ended nature of the problem and its authenticity as professional practice were key characteristics that linked it to the PBL model. Students in their final semester of a four-year degree were accustomed to small group work but were challenged by the requirement to manage the work of multiple small groups in each class and to coordinate across multiple classes so as to avoid duplication of effort on curriculum materials. Earlier activities in the semester had built capability for small group work but the students were not well prepared for the larger management challenges.

Despite the practical relevance of the task and the experience of the students there were still isolated instances of group members failing to contribute appropriately. This presented a further challenge because assessment was based on the collaboratively prepared materials and there were issues of equity around non-contributing students receiving credit. These required the tutor to facilitation negotiations among students to ensure equitable outcomes.

A course to be offered in 2011 will use a comparable whole cohort problem and similar challenges can be anticipated. The management challenge will be addressed by engaging students in preparatory activities early in the semester and providing appropriate communication tools through the LMS to facilitate coordination. Equity in assessment based on collaboratively produced artefacts will be addressed using a peer assessment tool such as WebPA (http://www.webpaproject.com/) to moderate marks.

6.2.2. Scaffolding with sub-tasks

Preparing staff and students was a substantial challenge to be faced in adopting PBL for a course to be offered to 500 students across three campuses and by distance education. Because the course was offered in the first semester of the four-year education program, students would have no prior experience of PBL or university study and would need support to develop the necessary capabilities. Staffing of the course was largely unknown during the planning phase and likely to be subject to variation so there was no guarantee about staff capabilities for a PBL approach.

In this case the challenge was met by applying insights from previous work on designing IMM-PBL [18, 20]. Because the course was intended to develop academic literacy, the major assessment was a position paper, the development of which constituted the target 'problem'. Consistent with the IMM-PBL approach, a series of sub-tasks was developed to scaffold students working individually and collaboratively to develop their paper and a small group presentation based on the content of the paper. The series of sub-tasks was bound together around a narrative thread, as proposed for IMM-PBL, to provide coherence among the components. Taking this approach provided support for students and staff in the course design and assisted both to adopt approaches consistent with PBL. The scaffolding was successful in supporting student performance on the major assessment.

7. Conclusion

The relevance and benefits of PBL as an approach to education of professionals have never been clearer. The changes we are experiencing in this early part of the twenty-first century require changed approaches to education and PBL seems to be particularly well suited to developing the twenty-first century skills needed by the new generation of professionals.

Implementing PBL is not without its challenges. They attach to all aspects of PBL, including changes in student and tutor roles, collaboration among students, design of curriculum and assessment, and application of technology.

For those who believe in the efficacy of PBL, an appropriate response to the challenges of implementing PBL may be to treat the implementation as an instance of PBL. It is an authentic problem of practice for an educator and applying the PBL approach can lead to solutions to the immediate challenges of implementation and to learning that will have application in future instances. Each of the examples described above has exhibited these characteristics, a working solution to an immediate problem and lessons for the future.

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