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Problem-Based Learning: More Problems for Teacher Education

Review by Tan Oon Seng

Introduction

The 21st century signals an era of unprecedented breakthroughs in technology and major changes in many aspects of life. The advent of the knowledge-based economy, the rapid proliferation of information technology, information accessibility, globalization, new industrial and business demands and changing political and social landscapes all lead to a call for new paradigms in education. In Singapore the need to refine our educational system to foster creative thinking, entrepreneurial spirit and lifelong learning has been repeatedly articulated (e.g. Ministry of Trade & Industry, 1998; Ministry of Education, 1998; Economic Development Board, 1999). In a recent university survey employers ranked as most important the following eight skills: teamwork, problem-solving, ability to take initiative, desire to learn, interpersonal skills, ability to work independently, oral communication and flexibility in applying knowledge (National University of Singapore, 2000).

It can be argued that in order for teachers to help students take greater responsibility for their own learning and develop relevant real world competencies, such as teamwork and problem-solving skills, teacher education itself should model and reflect such practices. Traditionally, teacher education emphasizes the importance of constructivism in education. Maddux & Cummings (1999) observed, however, that in reality teacher educators often employ frameworks of pedagogy that are easily identified as didactic, with "transmission of knowledge" methods. According to Korthagen and Kessels (1999) many teacher education programmes tend to adopt the "application of theory model". Whilst the emphasis on theory is an important aspect of teacher education, the problem with this approach is that knowledge drawn from various aspects of psychology and

sociology is often presented as fragmented slices in separate lectures or courses. Furthermore, as Carlson (1999) noted, although many teacher education programmes aim to begin with theory and move to practice, the experience of trainee teachers is often one of feeling underprepared for life in the classrooms.

So how can we revamp teacher education to meet the new challenges described and address the apparent chasm between teacher training and professional life? One approach that has been gaining attention in other professional training is problem-based learning (PBL). This review will describe PBL and how some of the concerns of professional training have led to the proliferated use of PBL in the field of medicine. It appears that some parallels can be drawn with the professional training of teachers. Finally, we will use a case in teacher education to illustrate how PBL is used.

PBL in Professional Training

Some of the earliest applications of PBL were in medical schools in the 1960s, notably Case Western Reserve University in Ohio, U.S.A. and University of McMaster, Ontario, Canada. One of the arguments for the use of PBL in medical education was "empirical evidence that medical students retain little of what they learn in the basic disciplines" (Bridges and Hallinger, 1995: 4). Furthermore, studies such as those by Balla (1990a; 1990b) found that medical students often used basic science knowledge incorrectly or not at all in formulating and revising clinical diagnoses. Traditionally, content knowledge has been taught separately from practice, in lectures. PBL advocates argue that this passive accumulation of knowledge (which is detached from the real world context) does not help learners apply knowledge to novel problem situations. Problem-based learning, on the other hand, does appear to address the gap between theory and practice.

In PBL, learning begins with meeting a messy, unstructured real world problem. The problem triggers the learning by having students define the problem, analyse the problem, generate hypotheses and identify learning issues. An example of a problem used by the Faculty of Medicine, Maastricht University (1991) is as follows:

> *"An eight-year-old boy has been lying under the water for more than 15 minutes. Fortunately a passer-by succeeds in getting him out of the water. Mouth-to-mouth resuscitation is applied immediately. Everyone is astonished to see the boy is still alive...."*

Medical students work in small groups (of about 5 students) to discuss the problem scenario. They ask themselves questions, such as what they know from the

case present, what they need to know, and what ideas come to mind. In the above case some of the questions raised were:

How is it possible that the boy is still alive?
How is it possible for him to recover completely?
Will there be water in his lungs?

Following such brainstorming and inquiry, students are expected to draw up their learning objectives and seek the necessary information on their own. In the group discussion facilitated by their PBL tutor, trainees refine their learning objectives into more pertinent questions that require the acquisition of deeper knowledge and insights important for their professional practice. In the above case their learning objectives might be stated in the form of questions such as the following:

What is the body's protective mechanism against (i) cold, (ii) hypoxia (lack of oxygen)?
What is the anaerobic system (when the body is not relying on immediate oxygen intake)?
What happens in the shift from aerobic to anaerobic dissemination?
Is oxygen needed for energy?

These questions then provide the parameters and motivation for learning. Thus, instead of attending a series of lectures on aerobic and anaerobic systems, the students interact with a problem that triggers their seeking of knowledge pertaining to these areas. The learning objectives are attained through self-directed learning and group discussions mediated by the tutor.

PBL is now used in most of the medical schools in USA (Bridges and Hallinger, 1995) and in Australia (Henry and Murphy, 1995). Many medical and health science programmes in the UK and the Asia-Pacific (e.g. University of Hong Kong and National University of Singapore) have also adopted PBL. Furthermore, interest in PBL has gained momentum across other disciplines, such as engineering, architecture and business (Tan *et al.*, 2000).

According to Albanese and Mitchell (1993) the positive effects of PBL include increased knowledge retention, integration of basic science knowledge, acquisition of self-directed learning skills and enhancement of intrinsic interest. In their meta-analysis of reported PBL studies from 1972 to 1992, the following major conclusions emerged:

- PBL students appear more capable of integrating basic science knowledge into the solutions of clinical problems;
- PBL students acquire more self-directed learning skills than do students in a conventional curriculum;

- PBL students are more intrinsically motivated to study the subject matter;
- Knowledge retention increases in PBL graduates.

The current concerns of teacher education include (i) developing teachers with competencies that meet the demands of a knowledge-based economy, (ii) effectively employing a constructivist approach in the pedagogy of teacher training, (iii) integrating knowledge from various disciplines, and (iv) closing the gap between theory and the real world classroom. Given the what, how, why of PBL and the observation of the current-state-art of teacher education, it appears that the arguments for PBL in professional courses apply in many ways to teacher education.

Characteristics of PBL

From a review of literature on PBL (e.g. Barrows, 1986; Schmidt, 1993; Boud & Feletti, 1997; Bridges & Hallinger, 1995; Savin-Baden, 2000) it can be said that the defining characteristics of PBL are as follows:

- The problem is the starting point of learning.
- The problem is usually a real world problem that appears unstructured. If it is a simulated problem, it is meant to be as authentic as possible. The problem calls for several sources of knowledge, so subject matter is organized around the problems rather than the disciplines.
- Self-directed learning is primary. Thus students assume major responsibility for acquisition of information and knowledge.
- Learning is collaborative, communicative and co-operative. Students thus work in small groups with a high level of interaction for peer learning, peer teaching and group presentations.
- Development of inquiry and problem-solving skills is as important as content knowledge acquisition for the solution of the problem. The PBL tutor thus facilitates and coaches through questioning and cognitive coaching.

PBL is based on the constructivist theory of learning (Schmidt, 1993; Savery & Duffy, 1995; Hendry & Murphy, 1995): Understanding is derived from interaction with a problem scenario and the learning environment. The engagement with the problem and the problem inquiry process create cognitive conflicts that stimulate learning. Furthermore, collaborative processes in learning in PBL require social negotiation and evaluation of one's understanding, and these in turn lead to the construction of knowledge.

It should be pointed out that an isolated exercise of problem-solving does not constitute PBL. Problem-based learning involves a whole curriculum shift. By a curriculum we refer not only to the intended set of the broad goals and learning outcomes, but all the experiences that the individual learners have in a programme of education. Tan (2000a) argues for a shift of three foci of preoccupations as illustrated in Figure 1.

As illustrated earlier in the medical example, it is argued that by using a "real life" or simulated *problem* rather than the *content* as a focus, students will really learn how to learn (Boud & Feletti, 1997). When we have real life problems (rather than content) as focal points, students are active problem-solvers, teachers are coaches, and the learning paradigm shifts towards the emphasis on and attainment of higher level thinking skills (Tan, 2000b).

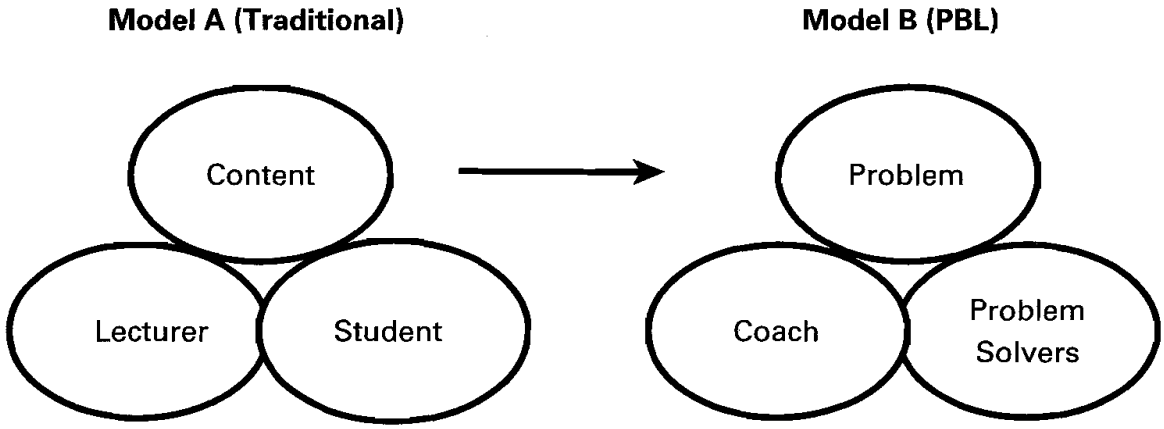

Fig. 1. A Model of Curriculum Shift

Illustration of an Application in Teacher Education

The following discussion illustrates the possible use of PBL in a core module of a Postgraduate Diploma in Education Programme entitled "The Psychology of Pupil Development and the Learning Process". At the start, trainee teachers are given the rationale for a PBL approach and told that the programme on learning theories will not begin with the usual dissemination of content knowledge or theories. PBL requires a mindset change on the part of students and calls for initiative, ownership and independence, i.e. what entrepreneurship is about. Instead of beginning with content knowledge, they will be confronted with a real world problem. An example of such a problem is shown in Box 1.

Box 1. Example of a Problem Scenario

Jerry, Seow Jing and Pakti have been good friends since they met two years ago at a charity gathering. It all started with some ice-breaking activities at that gathering and they discovered something in common among them – they liked to work with people.

Jerry was working as a banking executive for 2 years until recently, when his bank was re-organized and he volunteered to leave. Before working in the bank, he had taught as an "untrained" teacher for 6 months in a neighbourhood secondary school. He has just joined the teaching profession.

Seow Jing graduated from the NUS and has been working as a relief teacher at a government-aided primary school for about 2 months to "test " whether she would really enjoy teaching.

Pakti graduated from an overseas university and is planning to join the teaching profession. He has been relief-teaching at an independent school.

In a recent get-together they got into talking about their experiences with students. Seow Jing began:

"The other week I had to teach a primary four class how to solve some problems on volume. I really didn't know how I should do it, so I just gave them the formula L x B x H but I think many of them didn't understand.

"You should have brought a rectangular tank, poured in some water and shown them a real example," remarked Pakti.

"You're right. Then there was this word problem. Even I took quite a while to understand, and they're supposed to solve that, " lamented Seow Jing.

"Nowadays I think even at Primary One you're expected to add and multiply. I don't remember having to do that when I was six years old," said Pakti.

"Sometimes I wonder if the kids are ready to learn these things at that age. There must be certain ages where children are ready to learn something," added Seow Jing.

"You know, even with Secondary One students, I find it's not easy to teach them abstract concepts," Pakti added.

"So how do children and adolescents acquire concepts?" asked Seow Jing.

"Think of your own experience. How did you learn in school?" offered Jerry.

"I can't really remember, but I think people around me – my older brothers, parents and teachers – played a big role," responded Seow Jing.

Parki remarked: " For me I think it was discussing with my classmates that helped...."

Figure 2 provides a schema of the PBL process that trainee teachers go through in their first five tutorials. Between the tutorial sessions the trainees are engaged in self-directed learning which entails reflection, reading and research.

1. Meeting the Problem

At this stage the problem scenario acts as a stimulus to scaffold and extend a realistic context they might encounter in the future. The activities in this first tutorial include:

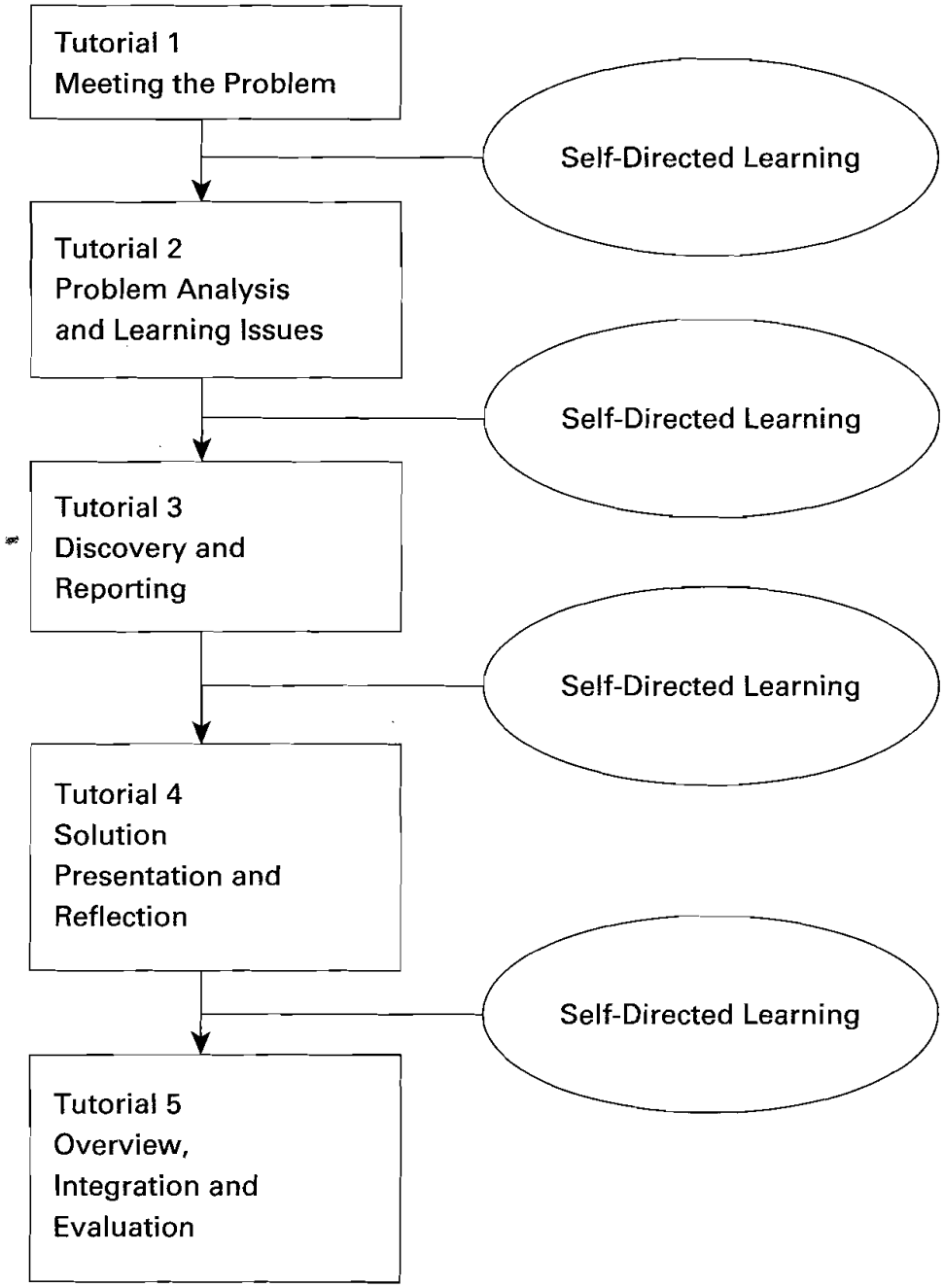

Fig. 2. PBL Process.

- developing collegiality;
- individual reading, reflection and inquiry;
- commitment to team roles and the group;
- brainstorming and articulation of probable issues;
- reaching consensus on the problem statement;
- deliberating on the problem scenario and problem analysis.

The following are two examples of statements from trainee teachers who participated in the PBL tutorial.

Group A:

As beginning teachers we realize that our prior experiences as students (the way we were taught) and even our recent experiences at the school attachment do not provide us with sufficient knowledge to understand many of the challenges going on in the actual classroom. Putting ourselves in the shoes of Jerry, Seow and Pakti we were concerned about addressing the issues of understanding how children and adolescents acquire concepts.

Group B:

As educational researchers we are interested to find out (i) how children learn, (ii) the role of peers, siblings, parents and teachers in helping children learn.

The purpose of the problem statement is for students to take ownership of the problem and come up with a global statement of the problem. Students work in groups of threes and each group presents their problem statements following their deliberations. These are further refined as they discuss in groups and as a class with the mediation of the tutor, whose role is to pose further questions rather than provide solutions. The tutor's interaction with the groups is aimed at developing skills in gathering information, reframing the problem and asking relevant questions. Following the first tutorial, students are expected to reflect on the problem statement and the issues raised.

2. Problem Analysis and Learning Issues

In the second tutorial, students analyze the problem and generate their ideas, possible explanations and hypotheses. The following are examples of lists generated by various groups pertaining to the problem scenarios.

Group A:

How do children and adolescents acquire concepts?

- *How does concept formation happen in the mind of a child?*
- *How does using concrete objects help learning?*
- *How does learning move from concrete to abstract?*
- *When is a child ready for different levels of knowledge?*
- *Are there certain prerequisites for the learning of certain mathematical concepts*
- *What is the role of language in learning?*
- *Do some children learn better visually?*
- *Do children have different preferences in terms of verbal, visual and kinesthetic styles of learning?*
- *What methods can teachers use to ensure that concepts are clearly understood?*
- *What strategies can teachers adopt to make learning meaningful and easy?*

Group B:

How do children learn?

- *Concrete to abstract?*
- *Breaking complex into simpler parts?*
- *Trial and error*
- *Correcting misconceptions?*

Role of peers, siblings, parents and teachers?

- *Support*
- *Modeling*
- *Socialization*
- *Breaking complex into simpler parts?*
- *Trial and error*
- *Correcting misconception?*

At the "Problem analysis and learning issues" stage the students' prior knowledge is activated and ideas are generated that call for further learning. The tutorial thus involves:

- Brainstorming and analysis of problem (e.g. generation of possible explanations, hypotheses)
- Identification of learning issues and formulation of learning objectives
- Assignment of self-directed learning and peer teaching

Here the tutor emphasizes the idea that real life issues are often fuzzy and, faced with a problem, we need to seek theories and sometimes multi-disciplinary knowledge bases to address the various issues we have to learn. The groups then proceed to make a list of issues amongst themselves and agree to seek information by researching from books, journals, internet resources and so on, and to come back with more well-informed explanations to the issues and questions posed.

3. Discovery and Reporting

Following the research and self-directed learning individuals in the group report their discovery of learning. At this peer teaching stage students gather to share the new information they have individually discovered. Thus some Group A members may return with references of Piaget's theories of cognitive development and related theories. Some Group B members may discover through their reading the works of Vygotsky and explain how his zone of proximal development may apply to the case.

Students thus practise group collaboration and communication skills through questioning and the seeking of further information from one another. The tutor's help ensures that key areas to be learned are not overlooked and that presenters are quizzed on the accuracy, reliability and validity of the information obtained.

4. Solution Presentation and Reflection

An iterative process follows with the discovery of learning, reporting, peer teaching and the presentation of solutions. As the students present their solutions to the problem scenario, a reflective and evaluative approach is taken. The students re-phrase and paraphrase the knowledge acquired and demonstrate their new knowledge. Sometimes more questions may be asked. The tutor facilitates the clarification of doubts, the awareness of gaps and correction of misconceptions or over-generalizations.

5. Overview, Integration and Evaluation

The integration of knowledge from various disciplines and sources and synthesis of ideas shared brings the problem-based learning to a closure. The review and evaluation of learning however forms an integral part of learning. Participants are encouraged to critique their learning resources (the value, reliability, usefulness for future learning). They reflect on the new knowledge they have learned as a result of the problem. At this stage, the tutor helps to summarize and integrate the major principles and concepts. The members of the group also evaluate their performance as problem-solvers, self-directed learners, and as members of the team.

Discussion

PBL can provide trainee teachers with opportunities to contextualize and apply the many theories of education. The potency of the PBL approach could be enhanced with a problem scenario that calls for a truly multidisciplinary approach, e.g. drawing on psychological, sociological and philosophical aspects of education.

PBL appears to address several desired outcomes of learning, such as independent learning, the ability to take initiative, teamwork and communication skills. Because of time constraints, however, the amount of content covered in PBL may be limited in comparison with traditional methods of dissemination. The

arguments for using PBL assume in some ways that one is prepared to sacrifice some content coverage in order to emphasise other desirable outcomes such as the learning to learn skills.

In terms of the constructivist theory of learning, PBL is learner-centred and relies on the individual's motivation for self, peer and collaborative learning. In many ways learners learn how to learn, as they are given the opportunities to find knowledge for themselves and compare their own understanding with that of others.

In many ways the pedagogy of PBL helps to make "visible", or explicit, the thinking and richness of cognitive structuring and the processes involved. One of the skills PBL students learn is how to ask questions and take an inquiry approach to issues.

Given the new challenges in education it can also be argued that having trainee teachers learn through PBL puts them in a better position to implement a similar approach to the teaching of their subjects in schools.

Conclusion

The advent of internet communication technologies has in some ways re-defined the roles of academics and ushered in new possibilities for PBL. As coaches, facilitators and designers of learning, the challenge is to empower students to make better use of the accessibility and range of knowledge. Furthermore, it is now recognized that the knowledge fields of this century will increasingly be characterized by cross-disciplinary integration. Biotechnology, the life sciences, telecommunications, material science and supercomputers are examples of corollaries of effective multi-disciplinary pursuits. Many of these pursuits originated from intense curiosity and the motivation to solve real world problems. In the 21st century classrooms and learning should thus focus on enhancing intelligence in the individual and harnessing intelligence from the environment. More time should be focused on helping students confront novel situations, sharpening their abilities to harness knowledge and developing fluencies in the heuristics of problem solving across a variety of disciplines.

In the light of global developments, our national education agenda, the review of literature on PBL and the successful proliferation of PBL curricula across many professional disciplines, teacher education should seriously consider a wider

application of PBL to some of its programmes. Implementation of PBL in teacher education, it is hoped, will lead to its introduction and use in our schools wherever relevant, for the PBL approach, with its constructivist basis, can be applied to student learning at various levels. The potential for PBL in secondary and primary schools will hopefully be explored and trialled by more and more beginning teachers as they experience and assess its probable benefits.

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