

**CRAFTING EFFECTIVE PROBLEMS FOR PROBLEM-BASED LEARNING,
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Abstract

Educators in higher education are constantly rethinking about how they can better prepare their graduates for their professional career. The medical faculty at McMaster University pioneered Problem-based Learning (PBL) in the 1960s as an innovative solution to make learning more relevant and effective. Since then, PBL approach in education has had proven success in many fields of studies, most notably in the areas of medicine, architecture, nursing and construction management.

According to Prof Howard S Barrows, “An authentic PBL education would require the student to go through the same activities during learning that are valued in the real world. The intent is to challenge the student with problems that he will be faced in practice both as a stimulus for learning and a focus for organizing what has been learned for later recall and application to future work.” The focus of learning is the problem itself. Students acquire new knowledge and learn by solving problems. Hence, the quality of problem is important for the full benefits of PBL to be realized. Due to educators’ own learning in the traditional education curriculum, most educators tend to craft problem based on their subject expertise. This violates the multi-disciplinary richness that PBL advocates. Being able to craft good problem becomes a critical skill for educators in PBL. This paper aims to describe the role of

effective problem for reaping the full benefits of PBL and to posit the principles of designing effective problem.

Introduction

According to Barrows and Tamblyn (1980), “problem-based learning (PBL) is the learning that results from the process of working toward the understanding or resolution of a problem”. Students learn by doing and hone their problem-solving skills. Through PBL, students develop hypothetical-deductive reasoning skills by acquiring relevant data, synthesizing the data and testing them through acquiring additional data (Wilkerson & Gijsselaers, 1996). The end result is an independent student capable of life-long learning.

The opposite of PBL is when learning is teacher-centered and subject-driven. According to Knowles (1975), what is required of the student in this teacher-centered learning method is that the student learns the material presented to him by his lecturer. He is expected to reproduce it as accurately as possible on demand. In this educational method, a student adopts “just-in-case” learning by covering all possible contents that he may be assessed on. Such learning is stressful as student cramps as much contents in a limited time. Learning becomes superficial. Knowing the contents does not translate to the ability to use this knowledge.

PBL is an education philosophy that engages the students, taps on their diversity in prior knowledge and promotes collaborative learning. The PBL rationale and philosophy are consistent with today’s continuously changing economic landscape. The challenge today is not just about supplying content and technical knowledge, but it is about being able to produce a new breed of employees who can create and manage the vast knowledge in the dynamic economy (Kek & Wee, 2000). In PBL,

students are self-directed and become motivated and active students. They practise “just-in-time” learning by seeking relevant knowledge to solve the problem on hand.

If PBL is the way to go for promoting relevant and effective learning, an immediate and critical step is to craft effective problem. This paper looks at the role of effective problem in reaping the full benefits of PBL and proposes principles in designing effective problem that work. A problem crafted by the authors for a marketing undergraduate class will be used as a case study to illustrate the principles of designing good problem.

The Role Of Effective Problems In PBL

In any PBL curriculum, the problems form the stimulus for learning. It represents the challenge that the students will face in their professional practice when they graduate. The problem provides the motivation and thrust for learning. It is from the problem at the onset, that students realize the limits of their existing knowledge and what they need to learn – from problem identification, filtering symptoms from the roots of the problem, hypothesizing the possible causes and effects, seeking relevant knowledge and generating possible solutions. The problem should allow the students to integrate across the various disciplines.

Hence, a good problem design is a non-negotiable skill that educators must have for successful PBL. Because PBL is a relatively new education philosophy, there are difficulties in implementing PBL. Albanese and Mitchell (1993) suggested that it is difficult to get the most out of the PBL potential if the two essentials of students’

learning are not factored in the implementation namely: the role of tutors and the format of the problem.

Principles Of PBL And Its Implications On Problem Design

The principles in designing problem are based on the authors’ belief in what PBL is and what can be achieved if PBL is implemented as an education philosophy. The principles in designing effective problems closely follow the principles of PBL.

In Table 1, the authors share their belief and definition of an authentic PBL model and its implications. Authentic PBL mirrors the demand of the work place. It requires students to perform the same activities in the learning environment as they would in the workplace. Hence, the problems must also be authentic. Merely crafting problem based on isolated expertise or subject matters without regard to how they relate to the real work demand will undermine the benefits of PBL.

Table 1: Elements Of PBL And Implications On Designing Effective Problem

Elements Of PBL	Implications On Designing Problem
<p><u>1. Constructive Approach</u></p> <p>Learning is a constructive process where students build new knowledge upon prior knowledge. It is not a receptive process where learning is just an act of filling up a student’s mind with information. Such learning can only allow a student to store the knowledge in memory and to pull them</p>	<p>Designing a problem that is obvious of its solution to a student is not effective. Here, a student is not allowed to build any new knowledge or information. The solution is so obvious to the student that this defeats the purpose of running a PBL process. The student will not be able to develop his</p>

<p>out when needed. It fits the filing cabinet analogy. However, reality extends beyond the filing cabinet analogy. It is full of discovery, exploration and updating. Modern cognitive psychology describes learning as a constructive process where the human memory is associative in structure. Knowledge is structured in associated networks of concepts and nodes, such that as learning occurs, new information is collected and coupled to existing knowledge networks. Such new information can then be easily retrieved and used to solve problems, recognize context, or to recall facts. New information is acquired through self-directed learning. Students are expected to learn about the world based on their own study and research. They determine their knowns and unknowns. They seek knowledge to address their unknowns. They engage in collaborative learning in their small groups to work on the problem.</p>	<p>reasoning and self-directed learning skills. This situation occurs when the problem looks like an instruction on what needs to be done, or appears like the title of a chapter, or contains only one way of resolving a problem.</p>
<p><u>2. Metacognition Level</u></p> <p>Learning in PBL encourages metacognitive</p>	<p>Problem that does not present opportunities</p>

skills among students. Bruer (1993) argues that learning is quicker when students possess self-monitoring skills generally referred to as metacognition. PBL is a learning and teaching philosophy that fully develops a student's ability at the metacognitive level, and not just mere problem solving like most other teaching methodologies. Successful problem solving is not only dependent on the possession of an extensive body of knowledge, but also on the use of problem solving methods to accomplish the goals (Gijsselaers, 1996). Few problems in everyday life or professional practices present themselves with all the relevant information that is needed to understand them well to make accurate decisions; more information is always needed. Some of the needed information is obtained by investigating the problem, making observations, conducting primary and secondary research, asking questions, probing and investigating. For a student to determine what needs to be investigated or what questions to be asked

for the students to reflect, deliberate are not effective in a PBL curriculum. The problems must be unfamiliar, unusual, new or perplexing enough for the students to engage their metacognitive level to discover and uncover, to reflect and review, to deliberate and explore, in directing them to the decision path they believe is valid. Only when a student is confronted with a abstract, uncertain, unexpected or puzzling situation or problem, will he ask himself such questions as: What am I going to do? How am I going to do it? Did it work? Hence, if a problem looks suspiciously like a past year's examination question, end-of chapter summary, or a fantasy-fictitious scenario, it will probably not be effective in a PBL curriculum.

requires much reflection, thought and deliberation. Such thoughts, reflections and deliberations are described as metacognition (Barrows, 1992). Metacognition is viewed as an essential element of skill learning: goal-setting (What am I going to do?), strategy selection (How am I going to do it?), and goal evaluation (Did it work?) (Gijsselaers, 1996).

3. Authenticate Real World

Problems form the organizing focus and stimulus for learning. Barrows (1996) posited that in PBL for medicine, the problems presented to students represent the challenge students will face in practice and provides the relevance and motivation for learning. The problem format has to present the problem in the same way that it occurs in the real world. For example, a medical problem has only the patient presenting complaints or describing his symptoms. Applying this principle outside the medicine domain, problems presented must closely mirror that of the real world in

Problem should represent the challenge that students will face in their professional career and practice. In short, problem should authenticate the working world demands. The problem should allow students to integrate information from the many disciplines when solving the problems like in the real world. Problems should not promote the isolation of disciplines as this is not realistic.

Hence, the problem must be real/ authentic and presented in the same format that they will occur in the world of work. Research

<p>which the students will face when they graduate.</p> <p>If the problem is as authentic as the real working world, it can stimulate the students in learning and also familiarize the students in the different learning contexts in their professional careers.</p>	<p>by Libshitz and Bar-Ilan (1996) had indicated that the ability to diagnose or recognize problems is directly related to the success or failure of developing solutions (Cooper & Loe, 2000). Likewise, familiarity with the context of the problem (i.e. recognition) also greatly enhances the ability to solve the problems (Price & Driscoll, 1997) in (Cooper & Loe, 2000).</p>
<p><u>4. Integrated Knowledge Base</u></p> <p>An authentic PBL curriculum integrates all relevant disciplines or knowledge. It promotes integration of disciplines and unites subjects in a traditional learning setting. This is because real work problem cuts across disciplines and blurs the lines between subjects.</p>	<p>A good problem is one that cuts across different disciplines or subjects. If a problem is anchored inside one subject, it artificially sets the environment for problem solving and the problem is subject-driven. In a real world scenario, a graduate will not be provided with subject-based problems to solve. Educators must start by identifying common yet high impact problems that their graduates must be able to recognize and solve. The subjects are then assigned to these problems. Problems should be industry-based.</p>

<p><u>5. Student-centered Education</u></p> <p>Learning is student-centered and students assume responsibility for their own learning agenda. They identify what they need to know and determine how to acquire the information to solve the problem.</p>	<p>Problem must be interesting and challenging to motivate the students to solve them. This helps to sustain their interest in a self-directed learning approach. Students determine their learning agenda by seeking out the unknowns needed to solve the problem. Educators acknowledge that students come with prior knowledge that will be activated. They will progress to learn their unknowns. Hence, learning is self-directed.</p>
<p><u>6. Small Group Learning</u></p> <p>Learning occurs in small groups.</p>	<p>The scope of the problem must reflect the manpower, time and budget constraints. Problems must be structured to encourage small group learning to solve the problems. Problems must be complex enough to require students to build on each other's knowledge and capabilities. They must learn to work in teams to solve the problem.</p>
<p><u>7. Role of Tutors as Facilitators</u></p> <p>Educators become facilitators and not</p>	<p>The problem should be presented in the</p>

<p>content-provider. As described above, a problem serves as a stimulus to learning. Triggering prior knowledge through small group discussions is a key variable in this process. Hence, a tutor must find the balance between allowing students to discuss the issues and facilitating to ensure that the key learning issues are met. Without this balance, an overtly passive or aggressively interfering tutor will violate the earlier principles of constructivism approach of understanding and the development of metacognitive skills.</p>	<p>same format as the real work. Tutors work as coach to monitor their students' learning journey.</p> <p>Facilitators should facilitate students in solving the problems. They should not give out answers. The ultimate goal is to make students more independent learners.</p>
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Principles in Designing Effective Problems

There are many different problem formats used by many different programs. As the problem is the stimulus in learning in PBL, setting up the problem itself is a challenging problem and must be customized to the industry standards. It is a painstaking process and few theory-based guidelines are available in the literature on how to construct a good problem (Gijsselaers, 1995). Hence, Gijsselaers argues that this makes it difficult to develop principles for effective problem design. He approached this issue by asking instead the opposite question: what features of problem design may reduce the potential of problem-based learning? Gijsselaers suggested a few based on his experiences at the University of Limburg:

1. Ineffective problem descriptions include questions that are substitute for student-generated learning issue.
2. The title of an ineffective problem is similar to titles of textbook chapters.
3. An ineffective problem does not result in motivation for self-study.

The authors attempt to posit a guideline for crafting good problems based on the principles of PBL:

Principle 1: Reflect Real Work Demands - Start with the End in Mind

Problems form the stimulus for PBL. Problems designed for students in an education should mirror those that the students will encounter in the workplaces to make them real work ready. In education, an authentic PBL requires the student to go through the same activities during learning that are valued in the real world (Barrows, 2000). Hence, educators should craft problems that help their students attain the exit outcomes expected of their graduates (Spady, 1994). To prepare students for their professional practice, educators can formulate a functional map detailing the likely outcomes that the students should be able to perform in their professional careers.

These exit outcomes are articulated and form the organized focus for all staff members and students to master during the course of study. Using a design down approach, exit outcomes are translated to problem outcomes (Spady, 1994). Achieving these problem outcomes would lead to the exit outcomes. Educators craft problems to help their students achieve the problem outcomes by solving the problem. These outcomes serve as benchmark for assessing the students' performance.

Effective problems always must be crafted with the end in mind for maximum benefits to future employers and maximum positive impact on society.

Educators are preparing the students for the world of change. Students should be able to hit the road running when they graduate. With these in mind, educators need to craft problem that mirrors the real world challenges. Problems must be presented in the same format as they are found in the professional practices.

Principle 2: Constructivist Learning Approach - Problems Must Build on Prior Knowledge

PBL is a powerful philosophy that empowers the students to take charge of their learning agenda. To do so, students must be motivated to solve these problems. The problems must be written in an interesting format that challenges the students to think. The problems should not be disguises of instructions. Educators should always check to see if their problems are motivating enough to solve from the students' perspective. Problems should provide sufficient opportunities for students to conduct research and study on their own, building on prior knowledge and expanding on associative networks of information. Prior knowledge information is engaged as the student is exposed to a range of diverse situations, promoting the transfer of knowledge to unique situations presented in the problem.

Problems crafted should be real-life or similar to the situations that students will face when they graduate. Students are motivated more by real-life problems compared with "ivory-tower" problems that they will never face in the real world. Many of the

traditional problems in lecture-based teaching are designed to test the understanding of theories and application without direct relevance to the real world. Problems should be as current as possible. Few students would be motivated to solve a problem set in the 1980s or earlier.

Principle 3: Enhance Metacognitive Skills – Produce Reflective Students by Setting Challenging Problems

Few problems in everyday life or professional practices present themselves with all the relevant information that is needed to understand them well to make accurate decisions; more information is always needed. Some of the needed information is obtained by investigating the problem, making observations, conducting primary and secondary research, asking questions, probing and investigating. For a student to determine what needs to be investigated or what questions to be asked requires much reflection, thought and deliberation.

Problems that do not present students the opportunities to reflect and deliberate are not thought provoking enough, and will not be effective in a PBL curriculum. The problems must be challenging, unusual, new or perplexing enough for the students to engage their metacognitive level to discover and uncover, to reflect and review, to deliberate and explore, in directing them to the decision path they believe is valid. Only when a student is confronted with a difficult or unexpected or puzzling situation or problem, will the student ask himself such questions as: What am I going to do? How am I going to do it? Did it work?

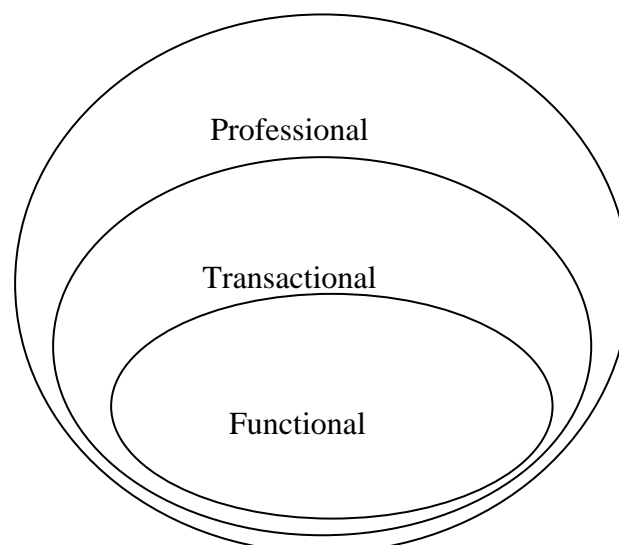
Principle 4: Integrate Knowledge Base - Promote Multi-Disciplinary Mindset

Students who study in subject mode tend to see subject expertise as a cluster of neatly divided silos. This way of learning promotes subject arrogance. Students may understand the underpinning knowledge within each discipline but may encounter difficulties in trying to integrate them. If problems are crafted based on subject expertise only, the students will suffer from a myopic mindset. PBL promotes multi-disciplinary mindset, through problems that reflect the real work demands that are multi-disciplinary in nature.

Case Study on Writing Problem based on a Marketing Education Curriculum

Adopting a customer-led orientation, the Diploma in Marketing (DM) at Temasek Business School, Temasek Polytechnic, explored the outcome-based education model in order to reinvent its marketing curriculum. Armed with a substantial funding from the Enterprise Challenge, Prime Minister's office in November 2000, the first step taken by DM was to determine the exit outcomes that the marketing graduates should be able to demonstrate upon completion of their studies. The DM exit outcomes in Figure 1 are reflected in three levels namely the Functional, Transactional, and Professional competencies (Wee and Kek, 2001).

Figure 1: Three Levels of Exit Outcomes



Functional outcomes refer to the acquisition of an integrated marketing knowledge that is gathered from solving marketing problems that a marketing graduate is likely to encounter in the work place. The graduate should be competent in performing the typical marketing problems found in the work place.

Transactional outcomes refer to the approach adopted by the graduate to perform his tasks. The graduate should be competent to conduct an efficient and effective problem solving process. The graduate should be competent to engage in group brainstorming, participate in active discussion, learn from peers, give and accept constructive feedback about self and peer.

Professional Outcomes refer to the personal skills and qualities that are desired and necessary of a professional marketer and his self-development. The graduate should be able to determine what he needs to learn in an efficient and effective manner that becomes habitual. The graduate should be professional and display high standard of conduct and practices of the discipline.

The engine that drives the DM outcome-based marketing education is authentic PBL. Table 2 illustrates the design of a marketing problem based on the proposed four principles in designing effective problems. The table also acts as a 'check-list or guide' for those wanting to pilot PBL and in designing problems for a PBL curriculum.

Table 2: Problem Design Sample

Level of Problem	Description	Principles At Work
Problem	<p>Memo</p> <p>To: PR executive</p> <p>From: PR Director, ABC PR Agency</p> <p>Date: 2 July 2001</p> <p>The agency just received an invite to pitch for an account for Hotel 81. The Board of Management of Hotel 81 has received negative publicity in last week's papers. The Hotel 81 management is not very happy and is concerned about its image.</p> <p>You have been asked to submit a PR proposal and pitch to the Board of Management of Hotel 81 on 15 September 2001.</p>	<p>P1</p> <p>Authenticity</p>
Prior Knowledge	<p>Marketing Tools, Customer Psychology, Marketing Intelligence, Marketing Environment, Customer Communications, Customer Relationship Management, Technologies in Marketing</p>	<p>P2</p> <p>Constructivist learning</p>
New Knowledge	<p>Marketing Planning and Control, Contextual Marketing</p>	<p>P4</p> <p>Integrate with new knowledge</p>

			acquired
Learning Issues	How to conduct PR research How to use SPSS and other relevant research tool How to segment and target the groups to communicate with How to do situational and competitive analysis How to develop a strategy How to write a plan based on research conducted How to do a pitch presentation to win the account		P3 Metacognitive processing
Time Needed for Problem	10 weeks	Level of Difficulty	Difficult

Notes:

- P1: Authenticate Real Work Demands
- P2: Constructive Learning Approach
- P3: Enhance Metacognitive Skills
- P4: Integrate Knowledge Base

Conclusion

Problems drive learning in a PBL curriculum. Hence, it is essential that problems reflect the exit outcomes that are mapped out in the curriculum. We should adopt “the whole is greater than the sum of parts” mindset. Problems should be viewed in a holistic manner crossing the boundaries of many subjects rather than as fragmented pieces written to cater to isolated subjects. Problems should be industry-based and not subject-driven. A database of problems that mirror real world demands (and with different levels of difficulties) serves as a rich resource base for learning.

Educators should craft effective problems that motivate their students and prepare students for the real world by ensuring that their students achieve the desired exit outcomes (Professional, Transactional and Functional competencies) after they have solved the problems. This is a critical success factor of PBL.

The authors propose that the quality of problems should be reviewed regularly. The authors like to propose the sharing of such reviewed problems among educators through a dedicated PBL problem case-clearing house set up in the Asia Pacific region. This database of problems will serve to jumpstart new PBL users in their PBL journeys with these tried-and-tested problems that worked in learning environments.

The ideal state in PBL would be to get students to undertake a series of “borderless” PBL problems where students would have to use knowledge from all subjects under their Diploma or degree programmes. The solving of these PBL problems would encourage

the integration of knowledge and bring the “work place” into the classroom for tertiary education.

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