Assessing specific types of thinking in problem-based learning activities

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This paper offers a practical approach to assessing specific types of thinking in problem-based learning activities. Problem-Based Learning (PBL) enables the assessment of real world tasks that integrate specific types of thinking, content knowledge and related process skills. Central to PBL is the skillful use of specific types of thinking which make possible the meaningful application of knowledge in practice.

The paper firstly outlines a model of learning and thinking and shows how specific types of thinking can be systematically identified for PBL activities. It then considers ways in which such types of thinking can be assessed in a valid and practical manner.

INTRODUCTION AND CONTEXT

At the opening of the 7th International Conference on Thinking in Singapore the Prime Minister of Singapore, Mr. Goh Chok Tong, made reference to Singapore's vision for meeting the challenges of the future in the words, "Thinking Schools, Learning Nation" (The Straits Times, June 3, 1997, p.1). Indeed, *thinking* has become very much the buzzword in education in Singapore over the past year or so, which is not surprising given its heavy reliance on human resources and the need to prosper in a knowledge-based economy.

The growth of Problem-Based Learning (PBL) as an approach to curriculum planning and delivery is a popular response to this national initiative. This paper firstly specifies the role that PBL may play in terms of promoting thinking in the curriculum. Secondly, it offers a practical model of learning and thinking that enables a methodology for identifying specific types of thinking in PBL activities. Finally, it provides a framework for assessing specific types of thinking in a valid and practical manner. The approach presented has been derived from a three-year curriculum development project to promote critical and creative thinking in vocationally based curricula.

THE ROLE OF PBL IN PROMOTING THINKING

PBL is an excellent vehicle for promoting thinking in any curriculum. If well constructed and managed it will provide:

- Authentic learning tasks that mirror real world activities
- Integrated learning activities that naturally combine subject knowledge, types of thinking and other process skills
- Performance-based assessment opportunities that enable a more authentic assessment of actual competencies than traditional pencil and paper tests
- A means of developing independent learning by offering students more autonomy and choice in their learning
- Opportunities to enhance motivation by providing learning tasks that are more likely to be perceived as meaningful and interesting to students
- A framework for both a collaborative and active learning approach, whereby students have to solve problems through information resourcing, analysis and application

A MODEL OF LEARNING AND THINKING

A Practical Model Of Human Learning

There is no shortage of models and theories of learning. Indeed, it could be argued that the plethora of perspectives and terminology confuse rather than aid educational planning and, in particular, teaching. Of course, we know that learning is a complex multi-faceted process. As Kolb (1995) points out:

> To learn is not the special province of a single specialized realm of human functioning such as cognition or perception. It involves the integrated functioning of the total organism - thinking, feeling, perceiving, and behaving. (p. 148)

Furthermore, learners – actual people - are influenced by a myriad of psychological, social and situational factors that pervade their everyday lives. As professional educators we are well aware that student learning is not a simple product of some given educational input. Our best efforts may or may not be successful.

My specific concern here is solely to illustrate the key aspects of effective learning. In order to do this, I will use an example by way of illustration. I often ask experienced teachers the following question: “How did you become competent at teaching?” The following are some typical responses:

“I went on a course” “Did some reading” “Thought about what I was doing”
“Spoke to colleagues” “Trial and error” “Reflected on lessons” “Practice”

This list is not exhaustive but you may notice a pattern in the responses. I suggest that they can be essentially classified in terms of three broad dimensions:

1. Acquiring Relevant Knowledge

All learning involves the acquiring of some knowledge, though the extent of this would vary depending on what is to be learned. Learning a language, for example, requires much knowledge acquisition. However, even in skill-based activities like playing football, there is still important knowledge to be acquired for effective performance, for example, the rules of the game. The key mental process involved in knowledge acquisition is memory.

2. Thinking For Understanding

However, the mere acquisition of knowledge through memory is often not sufficient for effective learning. Learners need to make sense of what they have learned and know when, where and how to use knowledge. Understanding the knowledge acquired is, therefore, fundamental to effective learning in most cases. The key mental process in understanding is thinking.

3. Doing

Effective learning in most cases involves actually doing the activity which, in turn, aids knowledge acquisition and understanding. The learning of skills and developing competence requires practice over time. For example, try to juggle three tennis balls or play a 3-cord sequence on a guitar assuming, of course, you do not have these skills already. The need to actually *do* the activity equally applies to all areas of human performance, not solely physical skill acquisition.

These three dimensions of learning do not occur as separate processes, but are dynamic and mutually support the effective development of competence in given areas of performance. They can be represented as a model in Figure 1 below:

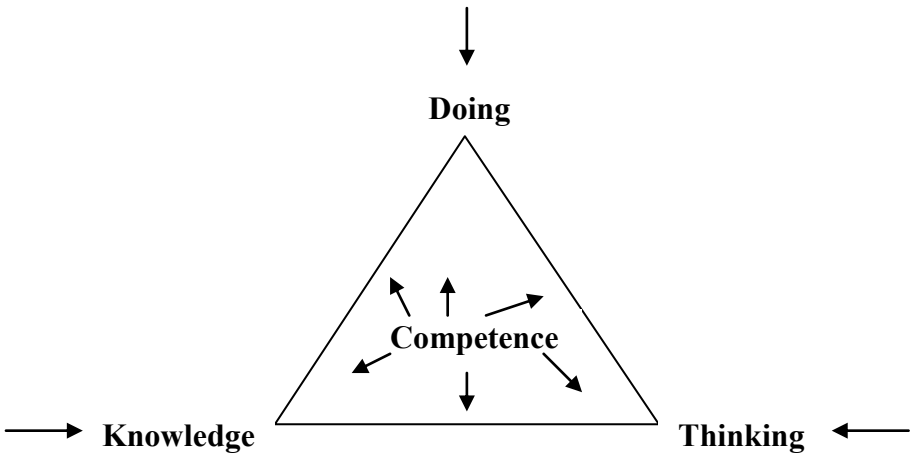

Figure 1. Model of Learning

This model of learning underpins the whole pedagogy of PBL. It recognizes the importance of knowledge in effective learning, but sees the learning process driven more from the standpoint of real world activity and the thinking process that translates knowledge into competent performance.

A Model Of Thinking

There is also no shortage of models and theories of thinking (for example, Marzano, 1988; Perkins, 1985; Swartz and Parks, 1994). Once again, this results in confusion in trying to systematically integrate thinking into a curriculum plan. If we fail to achieve a sufficiently clear conception of what we mean by thinking, it is unlikely that we will either teach or assess it systematically.

From the perspective of this paper, thinking can be usefully conceived in terms of the following broad interrelated *types of thinking* (adapted from the work of Quellmalz, 1997), represented in Table 1 below.

Table 1
Types of Thinking

Types of Thinking		
Creative/Divergent Thinking	Metacognition	Critical/Convergent Thinking
• Generating many possible options • Generating a variety of types of possible options • Generating originality in possible options	• Monitoring, evaluating and revising own thinking	• Analysing components and relationships in a system • Comparing and contrasting options • Making inferences and interpretations from data • Evaluating the relative worth of options

These types of thinking are essentially the cognitive components of problem solving. Problem solving is typically the well-orchestrated use of these types of thinking. However, it must not be assumed that any particular PBL activity will involve all these types of thinking. Furthermore, the more complicated and open-ended the problem, the greater the range and complexity of the types of thinking needed to tackle it.

THE NATURE OF PBL ACTIVITIES

PBL activities can vary in terms of size, structure and discipline involvement. However, they will involve learners in:

- Using specific types of thinking that are important for problem solving, for example, analysis, comparison, inference, evaluation, etc
- Accessing, organizing and making sense of relevant content knowledge, for example, the central concepts, principles and models and factual data pertaining to problem solving
- Developing other process skills that are important for promoting learning in the identified areas. These may include skills in communication, searching for and organizing information, etc

ASSESSING SPECIFIC TYPES OF THINKING IN PBL ACTIVITIES

The methodology documented below has evolved from working with many teaching professionals across a wide range of subject areas, age and ability ranges. Essentially, the following 3 interrelated steps need to be carefully addressed in producing a valid and practical assessment framework:

Step 1: Define The Types Of Thinking To Be Assessed

It is firstly necessary to define as clearly as possible the types of thinking to be assessed in a particular PBL activity. Learners need both awareness of how highly competent professionals think when solving real world problems and plenty of opportunities to develop and practise these types of thinking – indeed the rationale for PBL. To identify the types of thinking involved in any PBL activity, an essential starting point is to ask the question:

How Would A Highly Competent Person Think In Attempting To Solve This Problem?

A useful technique to identify the key types of thinking is to visualise the activity and ask the following critical questions:

- What are the important questions I need to address in solving this problem?
- What information sources will I need to access to find relevant knowledge?
- What actions will I need to take in solving this problem?

Experienced professionals typically solve problems from a set of developed heuristics derived from their professional stocks of knowledge over time. Underpinning these heuristics are the types of thinking outlined earlier, but it is essential to identify how they are specifically contextualized to tackle a particular real world problem scenario. As many new problems are usually variants of previous problems, the thinking process is shortened and *recipe* type solutions can be quickly applied. It is only when the problem has a degree of unfamiliarity that the professional is forced into a more extended thinking process.

For many teaching professionals the ability to make conscious and identify the types of thinking embedded in these heuristics can take some time initially and is most profitably done in a course team context. The difficulty is that experts, in any field, usually take for granted the types of thinking involved as these become automatic and tacit over time. However, in working with teaching professionals across many subject disciplines, once this 'problem' is recognized, they soon become able to identify the types of thinking involved in problem solving activities.

For example, from a law module, where part of the PBL activity involved the ability to be able to *'predict the possible legal outcomes in the event of a breach of contract', the* supervising tutor identified the following types of thinking as fundamentally important in competent task performance:

- Analyze the components of a contract
- Compare and contrast the expected and actual behavior of defendants
- Make inferences and interpretations concerning the behavior

- Evaluate the possibility of specific outcomes

Similarly, in a civil engineering PBL activity, where learners were presented with an engineering problem (for example, soil subsidence), the assessing lecturers identified the following important types of thinking:

- Analyze the problem from the information sources available
- Compare and contrast this problem with similar problems experienced
- Make inferences and interpretations and decide on further investigation avenues and information needed
- Evaluate possible solutions to the problem and decide on a course of action
- Monitor and justify the solution implementation process

Failure to apply these types of thinking to the subject content knowledge available would seriously jeopardize success in the task outcome.

Step 2: Identify Appropriate Sources Of Performance Evidence

Types of thinking pose certain problems for assessment because, as internal cognitive activity, they are not directly visible as processes. We need, therefore, to infer such *behaviour* from available sources of learner activity (performance evidence) such as:

- The product evidence from a learning activity
- Structured questioning of learners concerning if and how they are doing these types of thinking
- Observation of learners as they go about tackling the activity

PBL activities typically involve learners in a series of interrelated tasks as they work towards problem solution. In doing these tasks, they will produce direct product evidence of their work, for example, written reports, physical models, oral presentations, etc.

However, while the product evidence of PBL activities will provide an indication of how well learners have employed specific types of thinking in the problem solving process, it may not necessarily provide valid insight into:

- How these types of thinking were employed at particular times in conducting various tasks
- Who has actually done the thinking (this is often a problem in group-based activities and 'take home' activities)
- Learners' ability to monitor and evaluate the quality of their thinking

For this reason, the use of questioning is a particularly useful approach for authenticating the application of types of thinking in a PBL activity. Questions must specifically cue the types of thinking to be assessed. For example, in assessing how well learners have employed skills in evaluation, questions must ask learners to identify and justify the following:

- The basis of criteria employed in evaluation

- Prioritization and weighting of criteria
- How criteria are actually used in the decisions made

The observation of students as they go about PBL activities will provide further evidence relating to the employment of types of thinking. However, conducting assessment at the process level, while most valid for assessment, is not always possible given considerations of time and resources. A compromise usually needs to be made concerning validity and cost/resource effectiveness in assessment.

In summary, therefore, it is necessary to identify the particular types of performance evidence that we can assess, given the time and resources available. The greater the range of performance evidence available, the more likely we are to be in a position to make valid assessment decisions on learners' thinking. It is for this reason that portfolios are a popular assessment format for PBL activities as they provide opportunities for a diverse range of performance evidence over time.

Step 3: Produce A Valid And Practical Scoring System

The principles of good assessment apply equally to assessing types of thinking as for other performance areas. The development of competence here, as for other skill areas, requires plenty of practice and feedback. Learners will need to become familiar with these types of thinking and what is involved in competent thinking. It is, therefore, essential to adopt a strong formative assessment focus in developing competence in using types of thinking.

In summative assessment, it is necessary to employ a valid and practical format for purposes of recording assessment decisions and providing feedback. Both a checklist and rating scale/scoring rubric can be used as the basic assessment format. However, what is most important is that the types of thinking are sufficiently captured in the descriptors involved. For example, in a rating scale to assess if learners have effectively been able to *'compare and contrast the expected and actual behavior of defendants'*, the essential constructs of this type of thinking must be identified. These include:

- The elements of similarity between the expected and actual behaviour
- The elements of difference between the expected and the actual behaviour
- The importance and consequences of these similarities and differences

A rating scale/scoring rubric for assessing this type of thinking could be constructed as follows:

Descriptors	
Score 5	Score 1
All relevant areas of similarity and difference are clearly identified. The significant consequences are fully inferred and explained.	Important similarities and differences are not at all identified. Failure to infer consequences.

Scores between 5 and 1 would be qualitative variants between these top and bottom grading descriptors. It is often useful to write descriptors for all scoring options, particularly if the marks constitute more than 10% for a module or unit of study.

It is to be remembered that while each type of thinking has certain discrete cognitive operations, effective problem solving behaviour usually involves the well-orchestrated use of all types of thinking, as documented earlier. For example, in the compare and contrast example above, related types of thinking ('analyze the components of a contract', 'make inferences and interpretations concerning the behavior' and 'evaluate the possibility of specific outcomes') would also need to be effectively employed for the real world performance ('*predict the possible legal outcomes in the event of a breach of contract')* to be competent.

Using this format, learners are scored on how well they have applied knowledge critically to show that this type of thinking had been systematically employed in the task. In focusing on assessing the type of thinking, there is no minimizing the importance of subject content knowledge. The position taken in this paper is consistent with that of Paul (1993) who argues that:

> Thought is the key to knowledge. Knowledge is discovered by thinking, analyzed by thinking, organized by thinking, transformed by thinking, assessed by thinking, and, most importantly, *acquired* by thinking. (p. vii)

It is important to emphasize that the checklist or rating scale/scoring rubric does not make the assessment decision, but should provide a valid framework in which the performance evidence can be evaluated against. Assessors will also need to develop shared understandings of what constitutes appropriate evidence and standards for the types of thinking being assessed.

SUMMARY

While education is a *creature of fashion*, I would foresee PBL to be a significant component of curriculum organization for the reasons outlined earlier. The emphasis on process – of which types of thinking are a significant part – rather than content per se, makes more demands on the assessment system than traditional paper and pencil tests. Invariably assessment must become predominantly performance-based, as learners are involved in authentic real world activities.

In this paper I have introduced a methodology for assessing types of thinking in PBL activities. It recognizes the difficulties of assessing complex performance activities that involve considerable professional judgement. Most importantly, it emphasizes the need to systematically explicate the types of thinking underpinning real world PBL activities for valid assessment in this area. Further research is invariably needed to validate and refine the model of thinking presented here. However, the approach offered constitutes an attempt to move beyond the conceptual differences of defining thinking and focus on what professionals do in the real world of problem solving.

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