THINKING SKILLS, CREATIVITY AND PROBLEM-BASED LEARNING

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In this era of unprecedented breakthroughs in technology and constant change in many aspects of life, educators are challenged more than ever before with the need to develop graduates who will be adaptable in fast-changing environments. This calls for equipping students with better thinking skills and learning abilities. Concomitant with the quest for the development of skills pertaining to creativity and enterprise is the call for a paradigm shift in education. In the light of these developments a thinking programme was rationalized and conceived. The programme aims (i) to enhance student's capacity to learn how to learn, (ii) to enhance problem solving abilities, and (iii) to enhance students' capacity to adapt and confront change. These aims were consistent with enhancing students' abilities to learn and cope with the problem-based learning curriculum which was gradually introduced into the academic curriculum of the institution where the study was conducted. A problem-based learning approach (known as Problem-based Creativity Learning) was used, in particular, in modules of the thinking programme pertaining to the development of creativity. A study of the effects of the PBCL on creativity was reported and the results and implications were discussed.

THE CALL FOR CREATIVITY AND ENTERPRISE DEVELOPMENT

The 21st century and beyond signals an era of unprecedented breakthroughs in technology and constant change in many aspects of life. Educators are therefore challenged more than ever before with the need to develop graduates who will be adaptable in fast-changing environments.

Since the beginning of 1990 Singapore has embarked on a policy of rapid expansion in higher education (Brown, 1996), particularly polytechnic education. The expansion of polytechnic education was in line with the national strategy to create a better trained workforce. Polytechnic education in Singapore is primarily concerned with preparing graduates for the world of work and entrepreneurship in industry and business especially in areas such as engineering, applied sciences, business and information technology. Human resource is the key to Singapore's economic competitiveness (Committee on Singapore Competitiveness, 1998). According to Porter (1990) there is a need for a more creative workforce as a nation progresses in economic development. Singapore is at the innovation-driven stage of economic development and Thurow (1992) has argued that an important consideration at this innovation stage is the upgrading of human and knowledge resources. This calls for equipping our polytechnic graduates with not only logical reasoning and analytical abilities but also creative abilities.

The role of education in bringing about a generation of thinkers is, in fact, not new. The general goal of thoughtfulness as a hallmark of liberal education has often been articulated but as Resnick (1987) observed the "teaching of thinking" to all students was a relatively new concept. In the United States the importance of teaching thinking has been much emphasized in the 80's (Costa & Lowery, 1989). In Singapore the concern for teaching skills in thinking has become the major agenda for education in recent years. The national agenda for emphasizing the teaching of thinking was intensified when June 1997 saw the launch of "Thinking Schools, Learning Nation" (The Straits Times, June 3, 1997, p.1) as a major vision of education in Singapore by Prime Minister Goh Chok Tong. The concern for "keeping pace with changes in the world" was repeatedly emphasised by the Ministry of Education (The Straits Times, July 31, 1997, p.1). The desired outcomes of education for post-secondary students were redefined to include characteristics such as the ability "to think, reason and deal confidently with the future" and "to seek, process and apply knowledge"; "innovativeness"; a spirit of "continual improvement"; "a life-long habit of learning" and an "enterprising spirit in undertakings" (Ministry of Education, 1998, p. 4).

THE NEED FOR CURRICULUM INNOVATION

Parallel to the quest for the development of thinking skills, particularly those pertaining to creativity and enterprise in a world of new challenges, is the call for a paradigm shift in education. Globalisation and rapid technological innovations call for new competencies. Content and technical knowledge easily become irrelevant in a rapidly changing world. Peterson (1997) noted there has been a revolutionary rather than evolutionary change in the environment of colleges and universities. Ramsden (1998) observed that the challenges included new forms of learning, new technologies for teaching and new requirements for graduate competence. Educators need to ask if the skills imparted are really transferable to the workplace. Teachers would have failed if they use learning processes that do not impact on lifelong learning. Indeed, the challenge is for educators to design new learning environments and curricula that really encourage motivation and independence to equip students with learning skills, thinking and problem solving skills. Employers are looking for attributes such as problem solving skills, adaptability, initiative, creativity, communication skills, technological literacy, real work experience, leadership ability, logic and reasoning, systems thinking and so on. To what extent do our education processes address these developments?

The call for curriculum innovation in Singapore is also featured in a report entitled "Committee on Singapore Competitiveness" published in November 1998. The report (Ministry of Trade & Industry, 1998) which focused primarily on Singapore's economic competitiveness devoted a section to discussing human and intellectual capital as a key competitive edge. The report noted that over last three decades Singapore has had a successful education system that supported a "production-based economy". The report (Ministry of Trade & Industry, 1998; p. 86) further argued that to "improve the longer term competitiveness of Singapore, we should refine our education system to help foster creative thinking and entrepreneurial spirit among the young". It stated that three major components of the educational system should be addressed: (i) the content of the educational curriculum; (ii) the mode of delivering this curriculum to students; and (iii) the assessment of the performance of schools.

The Economic Development Board in a publication entitled *A Knowledge-Based Economy* similarly emphasised that for "our knowledge-based economy to flourish, we will need a culture which encourages creativity and entrepreneurship, as well as an appetite for change and risk-taking" (Economic Development Board, 1999, p.3). Singapore also aims to be established as a world-class educational hub renowned for its intellectual capital and creative energy. The idea as articulated in the Industry 21 plan (Economic Development Board, 1999, p.15) is that of entrepreneurs, technopreneurs and academics being enriched by an "environment that encourages ideas, creativity and innovation". In another milestone report *Manpower 21: Vision of a Talent Capital* it is advocated that tertiary institutions need to adopt strategies to meet the nation's challenge of being a talent capital. The Manpower 21 report (Ministry of Manpower, 1999) again emphasised amongst other things the development of human and intellectual capital, especially "innovation and entrepreneurial capabilities".

Given these macro developments, Tan (2000a) argued for a curriculum shift succinctly illustrated in Figure 1. The curriculum needs to shift from Model A to Model B.

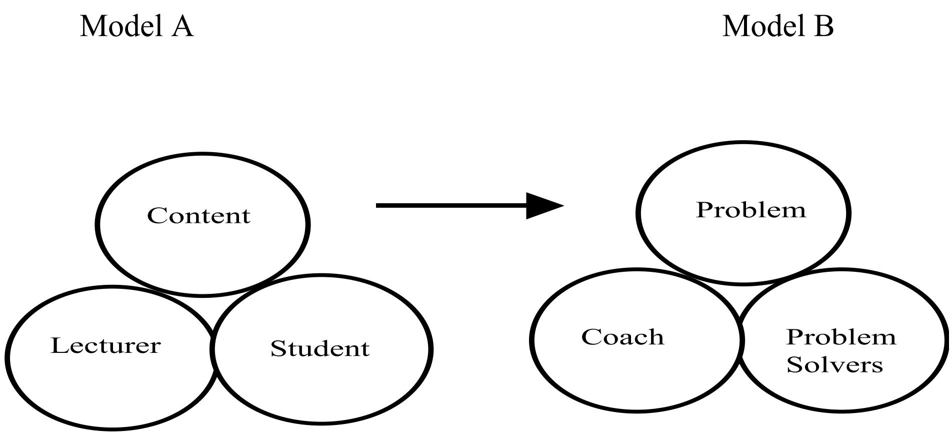

Figure 1. A Model of Curriculum Shift

In many ways this calls for a problem-based approach to the curriculum. It has been argued that by using a "real life" or simulated problem rather than the content as a focus, students would really learn how to learn (Bridges, 1992; Boud & Feletti, 1996). By having real life problems (rather than content) as focal points, students as active problem solvers and teachers as coaches, the learning paradigm would shift towards the emphasis and attainment of higher level thinking skills (Tan, 2000b). The search for educational methodologies that emphasise real world challenges, higher order thinking skills, multi-disciplinary learning, independent learning, teamwork and communication skills has a confluence in the holistic approach to problem-based learning.

PROBLEM-BASED LEARNING IN A THINKING PROGRAMME

In the light of global trends of change and the need to adapt, the expansion of polytechnic education, the call for more creative human resource and the national agenda for education in Singapore, a thinking programme known as the CMI (Cognitive Modifiability Intervention) was rationalized and conceived. The broader overarching aims of CMI were (i) to enhance students' capacity to learn how to learn, (ii) to enhance problem solving abilities, and (iii) to enhance students' capacity to adapt and confront change. These aims were consistent with enhancing students' abilities to learn and cope with the problem-based learning curriculum which was gradually introduced into the academic curriculum of the institution where the study was conducted. The theoretical underpinnings of the CMI were based on Feuerstein's Theory of Structural Cognitive Modifiability (Feuerstein et al., 1980; Feuerstein, 1990; Feuerstein & Kozulin, 1995) and Sternberg's (1985, 1986, 1990) triarchic theory of intelligence.

The CMI consisted of lessons under four major clusters of cognitive domains, namely, the Affective-Motivation Domain, the Systematic-Strategic Thinking cluster, the Analytical-Inferential Thinking cluster and the Divergent-Creative Thinking cluster. The CMI addressed these cognitive domains through an active modification approach. The programme consisted of 30 weekly lessons spread over an academic year. A problem-based learning approach was particularly used in the Divergent-Creative Thinking cluster which comprised modules involving the development of creativity. In this paper this shall be referred to as the Problem-based Creativity Learning (PBCL) programme. The PBL approach is illustrated in Figure 2.

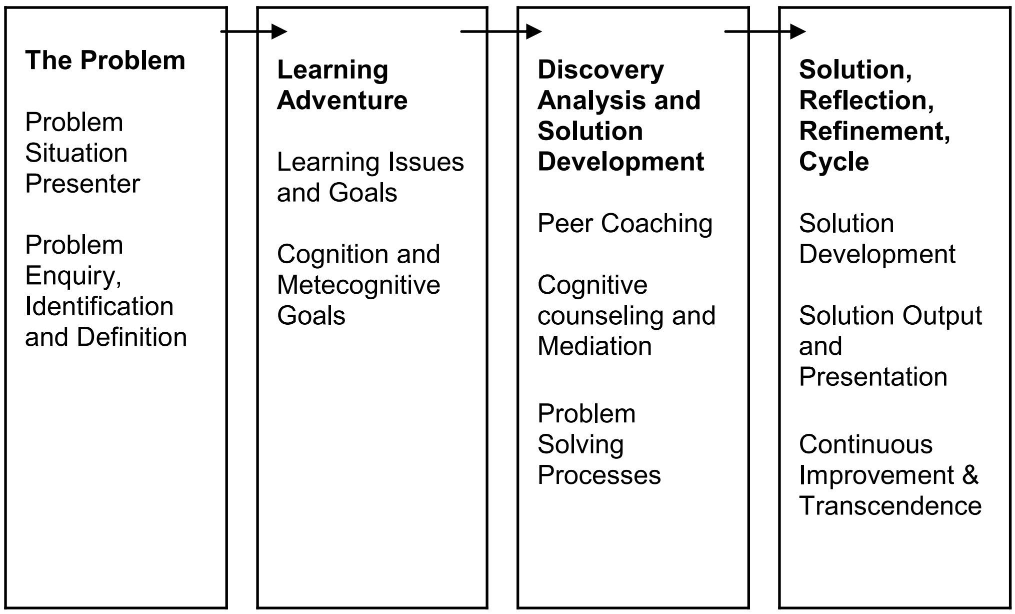

Figure 2. PBL in the CMI Divergent-Creative Thinking Cluster

The model is developed based on elements of PBL approaches advocated by Bridges (1992), Boud and Feletti (1996) and Trop and Sage (1998). Unlike PBL in academic subject areas, however, the emphasis is on cognitive and metacognitive learning as the "content" of the learning. The areas of emphasis in the PBCL are summarized in Figure 3.

The cognitive learning and metacognitive learning were based on cognitive functions pertaining to creativity drawn from previous research such as Guilford (1988), Finke, Ward and Smith (1992), Isaak and Just (1995) and Sternberg and Davidson (1995). Finke et al. (1992) proposed that creative thinking involves two distinct processing stages, namely, the generative stage and the exploratory stage. They propounded the Geneplore model which provided useful examples of cognitive processes, structures and properties. Isaak and Just (1995) pointed to the importance of "releasing unwarranted constraints" as part of the cognitive process of creativity and cited many interesting problems and cognitive exercises that may help highlight this cognitive function. Hence using an eclectic approach problem situations were created by the author on the basis of PBL approaches and the psychological development of creativity. The mediating principles of Feuerstein et al. (1980) were used in the PBL coaching process.

<table>
<tr><th>PBCL Module</th><th>Examples of Cognitive and Metacognitive Functions in Learning Process</th></tr>
<tr><td>Developing Multiple Perceptions

(Use of Mini-problems)</td><td>• Use of imagery
• Use of associations
• Use of analogies
• Mental blends
• Peer and team leverage</td></tr>
<tr><td>Unboxed and Unusual Thinking

(Use of Mini-problems)</td><td>• Release from unwarranted constraints
• Overcoming pre-mature closure
• Flexibility of thought</td></tr>
<tr><td>Creative
Problem Solving 1
(Problem Situation 1)</td><td>• Creative categorisation
• Creative elaboration
• Generative thinking
• Lateral thinking</td></tr>
<tr><td>Creative
Problem Solving 2
(Problem Situation 2)</td><td rowspan="2">• Problem definition
• Considering alternatives
• Unboxed thinking
• Creative persistence
• Refrain from impulsivity
• Harnessing all resources</td></tr>
<tr><td>Creative Thinking
(Problem Situation 3)</td></tr>
</table>

Figure 3. PBCL and Cognitive Emphasis

THE PBCL STUDY AND SOME FINDINGS

Methodology

The purpose of the study was to determine the effects of the PBCL programme on students' creativity.

The research sample comprised 158 first-year polytechnic students. A 2 x 2 x 2 factorial pre and posttest design with matched experimental and control groups was used. The three factors were treatment (experimental versus control), entry ability levels (high or low) and course grouping (Engineering or Applied Science).

Creativity in this study was defined operationally by the Cognitive Abilities Tests (Thorndike & Hagen, 1986) Nonverbal Battery. The Cognitive Abilities Test (CAT) provides a set of measures of the students' abilities to use and manipulate abstract and symbolic relationships. The emphasis of the CAT is on the discovery of relationships and flexibility of thinking. The Nonverbal Battery, designed to appraise students' discovery of and flexibility in manipulating relationships expressed in figural symbols or patterns, is made up of three sub-tests: Figure Analogies (25 items), Figure Classification (25 items) and Figure Synthesis (30 items). This battery measures students' fluid intelligence, which is not bound by formal school instruction.

Results

The results are shown in Tables 1, 2 and 3. The 2x2x2 ANCOVA on the CAT posttest using the CAT pretest as the covariate revealed a significant main effect for treatment, $F(1, 149) = 14.87$, $p < .001$. As shown in Table 3, neither the "treatment x entry ability" interaction nor the "treatment x entry ability x course interaction" was significant. There was a significant "treatment x course" interaction, $F(1, 149) = 4.75$, $p < .05$. The interaction indicated that Engineering students performed better than Applied Science students. Although the effect on creativity appears to be more effective for Engineering students, it should be noted that Tukey's post hoc test indicated that the difference is not statistically significant at .05. As expected the Tukey test (alpha = .05) indicated that for CAT scores (as a measure of creativity) there was a reliable difference between the experimental group and the control group in the Engineering course. There was also a reliable difference between the experimental group and the control group for the Applied Science course. The results indicate that within each of the courses the PBCL programme appears to produce significant gains in creativity abilities.

Table 1
Cognitive Abilities Test (CAT): Pretest and Posttest Means and Standard Deviations (SD) by Treatment Group

	Treatment Group			
	Experimental		Control	
	Mean	SD	Mean	SD
Pretest	55.97	7.65	52.57	11.40
Posttest	64.37	5.95	58.03	9.10
Difference	8.39	7.03	5.46	12.96

Table 2
CAT Means and Standard Deviations (SD) by Treatment, Entry Ability and Course Groups

	Entry Ability		Course	
	High	Low	Engineering	Applied Science
Experimental	64.17 (5.75)	64.59 (6.24)	65.56 (6.40)	63.08 (5.20)
Control	59.18 (9.28)	56.90 (8.90)	57.44 (8.04)	58.66 (10.20)

Table 3
ANCOVA Results for CAT Posttest Scores

Source	df	Mean Square	F
Treatment	1	759.80	14.87***
Treatment x Entry Ability	1	.08	.01
Treatment x Course	1	328.22	6.42*
Treatment x Entry Ability x Course	1	3.24	.06

*p<.05, **p<.01, ***p<.001

DISCUSSION AND CONCLUSION

The results of the study appear to support the hypothesis that the PBCL module can have reliable effects on creativity. Although the PBCL module built on earlier modules on thinking (which were not fully facilitated through a full PBL approach) the results were positive and promising.

The study reveals that both Engineering students as well as Applied Science students can benefit from a PBL programme aimed at enhancing creativity. It is acknowledged that other measures of creativity could have been used to give a better assessment of the diverse scope of creativity. Nevertheless, the non-verbal abilities in the Cognitive Abilities Tests refer to fluid intelligence, which relates to flexibility and fluency. These attributes are important given our recent emphasis in education. Furthermore the creativity cognitive functions such as associative thinking, analogy, imagery, taking multiple perspectives, release from unwarranted constraints, flexibility, fluency, originality, refrain from premature closure and elaboration are important to developing abilities related to learning to learn and problem solving.

That PBCL can produce statistically significant gains in creativity as measured by CAT is good news for educators in the light of the challenge to develop students to be flexible and creative thinkers. On the one hand, it points to the modifiability of students' abilities in these areas; on the other hand, it points to a possible intervention to bring about this development.

The study also points to the promise of further research involving interventions and curriculum integration of thinking and creativity development and problem-based learning. Further research could focus on other variables pertaining to creativity as well as more qualitative studies of the processes involved.

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