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Fostering Creativity from Constructivist Perspectives A Literature Review

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Abstract

In Malaysia, the current technology development and industrial demands has called for more graduates who are capable to creatively solve the complex engineering problems. Without creativity, graduates are facing difficulties, particularly in solving problems which concerns time efficiency, cost saving, and risk taking with regards to the output they produced. Within this, Problem Based Learning (PBL) appears to have potential in fostering students' creativity, by developing specific components of creativity. The literature review has been conducted to explore the potential of PBL from constructivist perspectives, which include the articulation on three components of knowledge, skills and attitudes. In summary, the literature review suggests that creativity is potentially to be fostered from constructivist perspective on the targeted components of knowledge, skills, and attitude. However, substantial evidences are needed by conducting more research in this body of knowledge in order to arrive at conclusive evidences.

Keywords: Creativity; problem based learning; critical thinking; creative thinking; constructivism

1. Introduction

The classical theory of education explained that the development precedes learning, and learning is the result of experience and both mental and physical maturation (Piaget, 1964). On the other hand, another educational theory was described in contradiction to the Piaget cognitive development theory, where the learning process leads to a development of higher order thinking (Vygotsky, 1978). This was explained by the Zone of Proximal Development (ZPD), which is the distance between the actual development level and the level of potential development. Based on this idea, Vygotsky has suggested that learning should apply the concept of scaffolding, whereby the students should interact with adults or peers to accomplish tasks.

It is believed that PBL has emerged based on the underlying theory of Vygotsky and Piaget. Nonetheless, some authors believed that PBL originates from theories including; contextual learning, discovery and inquiry learning, information processing, cooperative learning, and self determination theory (Albanese, 2000; Wee, 2004). Given with several theories, constructivist learning theory offers the most relevant explanation of PBL instructional approaches, and it appears to be agreed by all (e.g. Savery and Duffy, 2001; Hmelo-Silver, 2004; Kolmos *et al.,* 2007)

The PBL instruction is consistent with the principles from the constructivist learning theory (e.g. Camp, 1996; Savery and Duffy, 2001; Hmelo-Silver, Duncan and Chinn, 2007). Learning occurs from three primary principles; firstly, learning by a means to gain an understanding, which is a holistic process through interaction from the environment, secondly, learning is stimulated by a cognitive conflict, and thirdly, learning in terms of knowledge construction, which evolves through social interaction (Savery and Duffy, 2001). Knowledge construction is not an absolute but constructed through the interpretation of previous experiences on an existing knowledge structure (Schmidt, 1994; Savery and Duffy, 2001). The instructional principles

from constructivism align with the PBL instructional strategies in term of (Savery and Duffy, 2001):

i) Learning goal. Goals stimulate and engage learner within the problem solving process.
ii) Problem generation. Real problems determine the concepts and principles within the domain to be learned.
iii) Problem presentation. The problem engages students in an authentic problem solving and they own the problem
iv) Facilitator. The facilitator's role is to promote higher order thinking skills and encourage independent and self directedness.

2. The PBL emergence

PBL was originally introduced at the McMaster University in Canada as a method of teach physicians in medical education in 1965 (Barrows and Tamblyn, 1980). This effort was initiated due to the unsatisfactory performance of clinical students, particularly when dealing with real patients. Thus, Barrow and Tamblyn proposed a new way to engage students more in the learning experience. Students were presented with real world problem scenarios and they answered a series of questions in order to engage them in real learning processes. Soon after that, the method was known as PBL and in 1974 the McMaster Medical School PBL model was established.

The success of the McMaster PBL model had inspired other universities to implement similar designs in the medical curriculum. The University of Limburg at Maastricht and University of Newcastle in Australia were amongst the first to explore PBL as a potential pedagogy for its medical courses (De Graaff and Kolmos, 2007). The spread was triggered by the extensive research works in Maastricht which had introduced a number of innovations and evolutions (Schmidt, 1993). These innovations had spurred the emergence of other PBL models – e.g. in Australia (Brodie and Borch, 2004; Brodie and Gibbings, 2007) and across the world including Denmark (Kolmos *et al*., 2007), China (Zhang, 2002), Singapore (O'Grady and Alwis, 2002), Turkey (Bilgin, Senocak and Sozbilir, 2009), and Portugal (Oliveira and de Oliveira, 2009).

As PBL has been successful in medical education, there has been many efforts to implement PBL into others disciplines of higher education. To date, PBL has spread into chemical engineering (Zhang, 2002), electronic engineering (Mantri *et al*., 2009), engineering and surveying (Brodie and Gibbings, 2007), science education (Wong and Day, 2009), mathematics (Chamberlin, 2009), agriculture (Anderson, 2007), electrical engineering (Helerea *et al*., 2008), business and entrepreneurs (Mossuto, 2009), and other disciplines.

3. Defining PBL

PBL is an innovative teaching and learning method that resulted from the process of working towards an understanding or resolution of a problem (Barrows and Tamblyn, 1980). The problem itself creates a learning environment that triggers students to learn by experiencing the problem solving process (Woods, 2000). The PBL pedagogy advocates learning through the process of "learning by doing", and the facilitator roles to monitor this process by asking questions to trigger students' meta-cognition. Moreover, the process of problem solving is actually simulating the real world practice as have been practiced by the professionals. Further, this process typically involves a social environment through cooperation and collaboration (Brodie and Borch, 2004). Within this, we conclude PBL into two different perspectives, first students see PBL as a challenging and motivating learning method that triggered by real world problem as a kick start to knowledge construction. Second educators see PBL as an interactive teaching method that requires the process of monitoring and feedback to help student solve the real world problem.

4. PBL and creativity

The study of creativity has been dominant in mathematical field (e.g. Kwon, Park and Park, 2006; Leikin, Berman and Koichu, 2009, Chiu, 2009), to explore the components such as creative thinking, critical thinking skills, and mathematical problem solving ability. In engineering education, there is a limited number of studies that link PBL and creativity, which may leaves some gaps in the body of knowledge between instructional approach and creativity. Therefore the PBL effectiveness in fostering creativity remains elusive (Tan, Chye and Teo, 2009).

Although, a limited number of studies that directly explores the PBL effects on creative thinking, there is indirect way to link PBL and creative thinking, which is by defining it into a broad scope of creativity. This refers to the components that

made up creativity, which is based on Amabile (1983) framework of creativity. These are domain-relevant skills, creative-relevant skills and task motivation. A domain-relevant skills refers to an individual knowledge, basic talent for thinking, and may include technical skill with regard to specific discipline. Second component is a creative-relevant skills, which refers to an individual approaches to problems and solutions. It may also depend on personality, thinking, and working styles. The third component mainly involves intrinsic task motivation, which refers to self approach to a task, attitude, and self perceive about own ability.

4.1 Domain-Relevant skills

A domain-relevant skills includes the factual knowledge, understanding of concepts and principles, and may involve technical performance in a specific discipline (Amabile, 1983). The domain-expertise in skills provides fundamental basis for any creative performance to occur (Tan, Chye and Teo, 2009). Therefore, this literature review explores the effects of PBL approaches on knowledge and technical abilities, in order to provide basic understanding on the development of creativity. Sugrue's framework of domain-specific knowledge is used to describe the effects of PBL on knowledge structures. There are three levels of knowledge structures, which include knowledge of concepts, knowledge of principles, and knowledge of procedures (applications) (Sugrue, 1995). The remainder of this section will describe the effects of PBL on knowledge of concepts and principles, and then explore the effects of PBL on knowledge of applications.

Most of the studies employ special knowledge test to assess concepts, principles and applications. Some studies also use existing final examination to assess all these components simultaneously in evaluating a wide area of knowledge within the syllabus. Generally, the majority of findings indicate that PBL has positive effects on knowledge acquisitions, in the aspects of concepts and principles (Chang, 2001; Van den Bossche *et al.,* 2001; Cheng *et* al., 2003; Capon and Kuhn, 2004; Polanco, Calderon and Delgado, 2004; Akinoglu and Tandogan, 2007; Bilgin, Senocak and Sozbilir, 2009; Mantri *et al.,* 2009; and Wong and Day, 2009). On the other hand, several studies also indicate equal or negative effects on knowledge of concepts and principles, as measured by the study instruments (Matthews, 2004; Burris, 2005; Kasai, Sugimoto and Uchiyama, 2006; Anderson, 2007; Mergendoller, Maxwell and Bellisiomo, 2008).

In specific, for example in Cheng *et al.* (2003), the authors examined the effect of PBL on academic performance in *pharmacotherapeutic* examination. The data analysis demonstrated that the PBL students performed much better in knowledge test. However, the traditional method students fared much better in the final examination. Similar finding was illustrated in Akinoglu and Tandogan (2007), the PBL students had positive effects on academic achievement and conceptual learning with regard to the areas measured. Bilgin, Senocak and Sozbilir (2009) conducted a study to investigate the effects of PBL on students' performance on conceptual and quantitative problem, using the concept of gases as a subject matter. Both groups yielded almost same performance result in quantitative problem test, while the experimental group scored higher in conceptual understanding test.

Polanco, Calderon and Delgado (2004) contributed to the PBL research literature on knowledge of concepts and principles. In this study, tests and grade point averages comparison indicated that PBL students' academic achievement was significantly higher than their counterparts in the traditional method. Similarly, in Punjab Technical University, India, Mantri *et al.,* (2009) reported a study on PBL effectiveness in Digital Electronic Communication Engineering programme. The PBL students performed much better in knowledge test even though they lacked in confidence in the final examination. Likewise, the work by Chang (2001), Van den Bossche *et al.* (2001), and Capon and Kuhn (2004) across disciplines and populations, their finding also indicated the positive effects in favour of PBL students. Interestingly, the effect of PBL on knowledge of concepts and principles became more positive over extended time period as reported in Wong and Day (2009).

On the other hand, several studies indicated no significant changes in the knowledge of concepts and principles, when students are treated with either PBL or traditional lecturing approach. As a part of Mergendoller, Maxwell and Bellisimo (2008) study findings, the 12th grade students in California that were treated with PBL in Macroeconomic course, indicated no significant difference in knowledge test performance. This finding is accordance with Matthews (2004), whereby the knowledge and technical performance that were assessed using graphic multi-view exercises in the Engineering Graphic Course, demonstrated no significant difference in both controlled and experimental

groups. Similar findings were also illustrated by several other studies, i.e. in Kasai, Sugimoto and Uchiyama (2006). The studies that indicated negative effects of PBL on knowledge of concepts and principles were illustrated in Burris (2005) and Anderson (2007). In Burris, the knowledge gained by the traditionally supervised study method nearly doubled those in PBL group. Likewise in Anderson, the teacher-guided learning students indicated significantly higher in academic achievements compared to their PBL counterparts.

The studies that specifically examine the effects of PBL on the knowledge of applications are still scarce. Therefore, the effectiveness of PBL to promote the knowledge of applications remains inconclusive based on the available findings. The studies that reported negative effects, or no changes of two groups comparison in measuring the knowledge of applications (Van den Bossche *et al.*, 2001; Chang, 2001; Matthews, 2004; Anderson, 2007) are quite balance over the studies that reported positive findings (Capon and Kuhn, 2004; Kasai, Sugimoto and Uchiyama, 2006; Wong and Day, 2009). Even though these studies indicated tendency toward positive effects, more studies are needed to focus on the knowledge of applications. Since PBL is theoretically proven to provide an effective pedagogical approach, thus it should promote a learning environment which conducive for the knowledge of applications to grow.

In specific, Capon and Kuhn (2004) found that the PBL students possessed high ability in relating the concepts, understanding the meaning, and applying it in specific cases. Similarly in Kasai, Sugimoto and Uchiyama (2006), the knowledge application that was measured by the essay test, indicated that the PBL students scored higher compared to the traditional method of lecturing. This study was conducted in physical therapy education, which comprised of nine students in PBL experimental group and 11 students in the controlled group. In other context of comparison, the work by Wong and Day (2009) has proved that the PBL was effective on knowledge applications and performances. Based on the taxonomy of cognitive learning, PBL students demonstrated significant improvements in the comprehensions and applications of knowledge over extended time. PBL was found more comprehensive for knowledge retention.

The study that reported negative finding by Van den Bossche *et al.* (2001) indicated no effects on students' ability to apply knowledge in Macroeconomic course, when PBL was used as treatment. However the detailed analysis revealed that PBL students indicated the tendency to score higher at every level of knowledge structures. In a larger sample, Anderson (2007) had divided a total of 54 students versus 56 students respectively in the experimental and controlled group. The result illustrated negative effect on knowledge applications test. The PBL treatment leaves effects on content knowledge and retention, but not on higher order thinking ability. Similarly in Chang (2001), the author was using the Bloom's taxonomy of cognitive domain, which includes knowledge, comprehension, and application in developing science achievement test. The result indicated both groups performed at equal level of ability in knowledge of applications. Similar finding was obtained by Matthews (2004) study, whereby both groups performed at the same level in Computer Aided Design (CAD) test, which measures the knowledge of applications and performances.

Despite the tendency towards positive contributions to knowledge development, using PBL approach has led students to score lower in their final examination (Cheng *et al*., 2003; Burris, 2005). Most of the studies indicated that the traditional group students fared much better in the final examination, because the traditional lecturing method appears to be effective in delivering facts at large quantities. On the other hand, the PBL interdisciplinary learning advocated students to explore multiple areas of knowledge, and this may create some knowledge gaps within the course syllabus. As a result, the traditional method students outperformed the PBL students in final examination even though they latter were much better in knowledge retention.

Generally, studies on PBL effectiveness in fostering students' knowledge appear to be equivocal in findings even though there is a tendency toward positive effects on concepts and principles. These studies however are yet to provide adequate evidence in arriving at conclusive findings. In relation, the effectiveness of PBL in fostering knowledge of applications and performances is far from robust. Due to the limited number of studies focusing on those three levels of knowledge structures, more studies are necessary so as to provide convincing evidence in these areas.

4.2 Creative-Relevant skills

The creative-thinking skills describes on how an individual approach to problem and solutions or how people thinks (Amabile, 1983). This section mainly

discusses creative and critical thinking to represent the individual's higher order thinking skills. Creative and critical thinking are amongst the family members of the higher order thinking skills along with problem solving and decision making (Facione, 1990). The scope of discussion is limited to these two areas since the relevant topics might cover a wider area of discussion. The relationship between creative thinking and critical thinking are also discussed in details. The remainder of this section will initially describe the link between PBL and creative thinking, and then discusses the link between PBL and critical thinking ability.

The research indicated that the systematic training on the components of creativity such as fluency, flexibility, originality, and elaboration has led to creative thinking (Jianzeng *et al.*, 1997). Similarly, the systematic approach in PBL instructional method may also equip students with this competency. The potential of PBL as an effective instructional method to foster creative thinking is very encouraging. Several empirical studies that will be discussed may validate the statement through empirical evidences.

Several recent studies illustrated that PBL leaves positive impacts on students' creative thinking (Tan, 2000; Kwon, Park and Park, 2006; Awang and Ramly, 2009; and Chamberlin, 2009). Specifically, the PBL fosters positive development on creative thinking, by means of fluency and originality of problem solving (Awang and Ramly, 2009). The creative thinking is also valued by a divergent thinking, which refers to the components of fluency and originality, as well as the flexibility of creative thinking (Kwon, Park and Park, 2006). It also valued based on the novelty of creative problem solving, and the ability to solve mathematical problems in a unique method (Chamberlin, 2009).

These available evidences would shed light of the potential of PBL approach in fostering creativity. However, these evidences are far from adequate to prove PBL effectiveness in fostering higher order thinking skills as a whole. Therefore, the following literature review will look into critical thinking aspect, whereby the research in PBL is always linked to the development of critical thinking skills.

The link between creative and critical thinking can be described from several views. For example, Baker and Rudd (2001) argued that both are not closely connected, where the creative thinking is always linked to divergent thinking, while critical thinking is in contrast to be convergent. However, on the other hand, we are describing that the critical thinking skills is possibly one of the attributes of creative thinkers. This statement may be validated when Abrami *et al*., (2008) highlighted that creative thinking is an essential element of critical thinking.

In relation, Bailin (1987) and Facione (1990) asserted that creative and critical thinking are intimately connected, integrated, and both are thinking processes that lead to an effective thinking. Critical thinking is an analytical method to arrive at the judgment within a given framework. On the other hand, creative thinking is an imaginative and generative approach to solve the problem that breaks out of the framework. Bailin described that if one's faced with a problem, a creative individual will try to figure out as many solutions as possible. At the end of the process, one best solution is chosen and this requires critical assessment in making decision. Furthermore, the critical assessment requires knowledge and understanding of the problem at hand. This implies with the justification that critical thinking is considered in this literature review, along with the importance on knowledge to foster higher order thinking skills through PBL learning approach.

In critical thinking study, generally PBL is showing tendency, which is in favour of positive development. For instance, Kellog, Kellar and McDonald (1998) utilized special integrated module as a tool to develop several skills including critical thinking skills. The module was implemented using PBL and embedded with collaborative writing task. In brief, the finding indicated that the special module has improved students' critical thinking skills. In relation, in studying a characteristic of critical thinkers, Derry *et al*. (2000) had investigated the scientifically and statistically reasoning skills in problem solving amongst students in the University of Wisconsin-Madison. The students improved their ability to reason statistically when they presented their problem solutions. Furthermore in Burris (2005) study, the PBL instruction did not change the students' critical thinking ability.

As a part of the work by Polanco, Calderon and Delgado (2004), the engineering students in Mexican universities indicated no changes on their critical thinking ability after undergoing the PBL treatment. The result indicated that both groups had no difference on critical thinking ability even though the PBL students achieved slightly higher score in all the components measured. Similarly in Choi (2004), there was no significant difference between pre-test and post-test data for critical thinking aspect.

In longitudinal study, Tiwari *et al*. (2006) compared the effects of PBL and traditional lecturing approach on critical thinking skills. The study was conducted in the undergraduates nursing programme

in University of Hong Kong, for 1 year long PBL treatment. The result indicated that the critical thinking improved throughout the 3 years of the study in favour of PBL students. Students perceived that the PBL tutorial session contributed to their critical thinking skills development. The study concluded that PBL has positive impacts on the development of critical thinking compared to traditional method of instruction over long term duration.

With regards to creative and critical thinking literature review, PBL is seen to potentially foster students' higher order thinking skills. In spite of positive results on the study that directly links between PBL and creative thinking, it still lacks substantial evidence that can lead to robust and concrete conclusion. This scarcity has called for more studies that scrutinizes the different population and disciplines rather than focusing on the mathematical field. In relation, the study on critical thinking and problem solving appears equivocal and leads to inconclusive evidence. Critical thinking aspects however, provide hints that it would be most effective for long-term duration in PBL environments.

4.3 Task motivation

The third component describes that the intrinsic motivation is an internal force that drives individual enthusiasm to solve problems, and it contributes to an individual creative performance (Amabile, 1983). On the other hand, the extrinsic motivation is triggered by the external source that may or may not help one's creativity. The power of intrinsic motivation lead to an individual work perseverance, positive attitude and self perceived of ability, and thus produced creative works. The remainder of this section will describe a wide area of affective domain since the motivational variable relates to a wider areas including engagement in learning, efficacy, and attitudes.

Numerous evidences suggest that the PBL approaches lead to positive attitudes toward subject studied. The importance of positive attitude in learning is undisputable, since there is assumption said that the positive attitude possibly increases academic performance. The positive attitude might encourage students' engagement in learning, and therefore the academic achievement turn out to be more positive (Akinoglu and Tandogan, 2007). Similar findings were illustrated in Matthews (2004), where he found significant difference in attitude for both experimental and controlled group in favour of PBL students. Likewise in Mossuto (2009), students reported positive attitudes toward PBL approach and they have engaged more in the learning process.

Ahlfeldt, Mehta and Sellnow (2005) had conducted a large scale survey study for the specific research on engagement. They found that the course level, enrolment, level of PBL and academic stream were all good predictors for students' engagement in learning. This study illustrated that the high level of engagement occurred more frequently in upper level and smaller classes, when PBL was implemented. Similar findings were also illustrated in other studies such as in Mantri *et al*. (2009) and Kasai, Sugimoto and Uchiyama (2006).

In a specific study on motivation, Pederson (2003) had identified elements such as choice, challenge, control, and collaboration actually encouraged students' intrinsic motivation. The study found that students experienced motivation in the novel learning environment. In other relevant context, Dunlap (2005) has examined the students' efficacy in a PBL environment. The qualitative data finding was consistent with quantitative finding, whereas PBL has increased student's efficacy by making them feel prepared to work effectively in their profession. Similarly in Martin, West and Bill (2008), the data analysis indicated a positive development on students' motivation and self-esteem. In Anderson (2007), students' motivation profile was generally low, but high in extrinsic motivation, and scored moderately high in intrinsic motivation.

Most of the studies on affective domain have demonstrated positive changes in attitude, motivation, engagement, and self efficacy for PBL students compared to their counterpart in traditional lecturing method. Some research findings have also indicated that PBL has turned students' perceptions towards more positively and leads to more satisfaction (Tiwari *et al.,* 2006). Some of the study is in contrast, indicating no effects on attitude towards learning (Polanco, Calderon and Delgado, 2004). However in general, PBL presumably fosters high motivational level to increase academic achievements, and lead to creative performance. This conclusion supports the meta-analysis finding, whereby PBL contributed to students' positive motivation towards learning (Colliver, 2000).

5. Conclusion

The literature review suggests that the constructivist perspective is generally fostering creativity development, with regards to the Amabile's framework of creativity. This specifically refers to three components of creativity, which include domain-relevant skills, creative-relevant skills and task motivation.

Within this, the effects of PBL have been reviewed within three levels of knowledge structures, namely; concepts, principles, and procedures (applications). The literature review indicates that PBL has positive effects on knowledge acquisitions particularly on the aspect of concepts and principles. But this is true, when PBL is taught within the scope of the knowledge assessed. The traditional lecturing method appears to be more effective in inculcating large amount of concepts and principles within the intended syllabus. This explains why the traditional method students scored higher in the final examination. However, PBL students appear to be better at knowledge retention within the scope that covered during the problem solving process. The possible reason is that the knowledge is better structured in mind, so that they easy to achieve the knowledge when necessary.

The PBL approach appears to be effective in promoting students' learning at higher cognitive level, which includes application, analysis, synthesis, and evaluation using Bloom's taxonomy as reference. The knowledge of application in Sugrue's model is identical with higher level of cognitive domain in Bloom's taxonomy. Within this, PBL students show inclination towards positive development in knowledge applications, but this is still far from exhibiting robust evidences in arriving to a conclusion. If the time frame is increased to a longer duration, PBL approach appears to be more comprehensive at all levels of knowledge structures.

In the second component of Amabile's framework, PBL potentially fosters higher order thinking skills, which is in this case are both creative thinking and critical thinking skills. The findings indicate inclination towards positive effects on creative thinking, when PBL is used as a treatment. Due to the lack of evidence that directly links between creative thinking and PBL, another aspect of higher order thinking skills has also been described. The second discussion mainly focuses on the articulation of critical thinking and PBL. Indirectly, the discussion on critical thinking also includes discussion on problem solving skills, since it is used as a tool to measure critical thinking skills. Within this, the general conclusion indicates that PBL prone to produce positive effects on critical thinking skills.

In the third component, the studies that scrutinize PBL and affective domain typically involve several variables, such as motivation, engagement in learning, efficacy, and attitude. Most of the studies which investigate this domain typically incorporate them as additional elements along with the knowledge and skills domains. There is a trend to employ a survey study in understanding the link between PBL and affective domain. Fewer studies have focused on the effects of PBL as a single affective component of perceptions. However, overall findings have indicated inclination towards positive effects on students' motivation, engagement in learning, efficacy, and attitude.

This literature review shows that there is a knowledge gap in certain areas which requires further investigation. It is specifically to determine the effects of PBL instructions on knowledge acquisitions, creative thinking, critical thinking, and affective domain. With regard to these three domains, generally the research findings remain elusive, but it would shed light on the potential of PBL in fostering creativity.

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