How effective is the assessment of generic skills gained by Technical Vocational Education and Training (TVET) of engineering students engaged in Problem-Based Learning (PBL)? – A Literature Review

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Abstract

The review of the literature for this study focusses on PBL approach within the Technical Vocational Education and Training (TVET) of engineering, and the development of assessment on engineering students' generic skills. Key findings of the research point to four aspects: inter engineering disciplines; different cultures; different education policies; and world globalization with rapid technology changes; will be considered during designing the assessment. The identification and the development of measurable and reliable method for assessing the engineering students' generic skills through PBL approach are crucial to the overall success of the respective Technical Vocational Education and Training (TVET) institution.

Keywords: Generic skills, problem-based learning, assessment, technical vocational education and training (TVET), engineering;

1. Introduction

Graduates from higher education who grasps generic skills competencies during studies have added value in their career development. With the dramatic changes in technology, graduates should be able to digest, apply and distribute information with precision and ease. Young and Chapman (2010) commented in their research, employers who operate in global markets now seek employees who possess not only high-level technical or 'job-specific' competencies, but also, high levels of communication skills, problem solving and conflict resolution (p. 1).

The generic skills in this research refer to the problem solving, critical thinking, communication and life-long learning skills of graduates. Therefore, this paper aims to critically assess the effectiveness in terms of reliability, measurability and validity of the assessment methods of generic skills through PBL approach amongst Technical Vocational Education and Training (TVET) engineering students. To achieve the above aim, the paper begins by looking at the terminology of generic skills in different countries and the importance of generic skills at the workplace. The paper thus discusses the approaches used in the generic skills development especially in Technical Vocational Education and Training (TVET) perspective. The next part of the paper focuses on the generic skills assessment methods through PBL approach and the problems faced in verifying the assessment in PBL.

The paper concludes that the aspects in inter Technical Vocational Education and Training (TVET) disciplines, different cultures, different education system policies, and globalization alongside rapid technology changes will be given due consideration when designing the generic skills assessment. This research will contribute a positive impact on PBL assessment especially in Technical Vocational Education and Training (TVET) engineering students' generic skills achievement in a measurable context. Indirectly, it may also be deemed as a performance indicator of the Technical Vocational Education and Training (TVET) institution and Ministry of Higher Education respectively. This would be the focus of this research as emphasized in the research question and objectives.

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2. Background – Context: Generic Skills in Technical Vocational and Education Training (TVET)

Generic skills are the skills that students need to become more successful learners and successful practitioners in their field of study, work and other aspects of their life are an important outcome of university education (Allan & Clarke, 2007; Bennett, Dunne, & Carré, 1999; Biggs, 2003). The terminology used to refer to generic skills differs from one country to another. (NCVER, 2003). The terms includes: 'key competencies', 'soft skills', or 'employability skills' (Australia); 'key skills' or 'core skills' (United Kingdom); 'essential skills' (New Zealand); and 'necessary skills', 'employability skills' or 'workplace know-how (United States). Essentially, the terms refer to the same skills as shown in Table 1.

Though an academic qualification is the more important criterion that an employer looks for, what differentiate graduates from other graduates are their interpersonal skills, communication skills, critical thinking and problem solving skills. Hamzah and Abdullah (2009) suggested that any organization's portfolio should include the generic requirement for each job so that the prospective employees can make necessary steps to equip themselves for the job and know their competency level (p. 688). Lack of these skills will effect on job opportunities as reported in The Chronicle of Higher Education on 5th December 2011,

employers say college graduates lack of job skills and this is supported by Mail Online, London, England reported on 26th January 2012, that one in three top companies can't fill graduate vacancies: Too many leave university without the right skills, say bosses. While "Too many young people lack the social skills needed to get their first job" the statement appeared in the BBC News Education and Family on the 23rd May 2012. Jideani and Jideani (2012) stated "academic success is not in terms of what students can remember, but in terms of what students are able to do with their knowledge" (p. 34) which is also referring to the life-long learning capabilities.

Globalization and rapid changes in technology imply the need for workforces that not only have specialist knowledge and skills, but have developed the generic skills needed to adapt quickly to new emerging technologies (UNESCO, 2012). With respect to that circumstance, the education in the 21st century has had a considerable impact on learning and teaching approach adopted in further and higher education especially in the Technical Vocational and Education Training (TVET) engineering discipline. Typically, most of the technical and vocational subjects are still delivered using traditional of four step method training of Allen (1919) approach which starts with describe, demonstrate, try-out by trainee and evaluate with feedback. However, students trained via Allen (1919) approach are lack with the required generic skills by the employer such as problem solving, critical thinking, communication and life-long learning. Though generic skills are important for the graduates during the job hunting, it is also a need for them to acquire technical skills through hands-on experience that will enable them to solve problems which emulate industrial problems. Instead of spoon-feeding students with fundamental theories and ideas, Problem-Based Learning (PBL) is one of the active learning approaches that have been introduced as an alternative and integrated way in Technical Vocational Education and Training (TVET) learning and teaching (Masek & Yamin, 2010; Nur Sofurah Mohd Faiz, Mamat, Mohamed, Sulong, & Burhannuddin, 2008).

Technical Vocational Education and Training (TVET) have been known as an education and training system to produce highly skilled workforce and knowledgeable manpower particularly in modern careers. Political and economic leaders around the world acknowledge that the workforce skill level is what determines the economic performance (Benjamin et al., 2012). Consequently we witness the development of many vocational and technical training institutions and universities in the effort to fulfill these needs in developing or developed countries (Tabbron & Yang, 1997). Adopting PBL in engineering teaching approached have significantly improved the students' personalities and attitudes (Prince, 2004). Instead of curriculum development, learning outcomes and policies, assessment is the main criteria to measure the quality of the engineering students and Technical Vocational Education and Training (TVET) institutions. Currently, the assessment on the academics is very objective and well structured, which leaves the generic skills assessment to be subjective and immeasurable. A valid, measurable and up-to-date assessment method will be designed in order to measure the effectiveness of the Technical Vocational Education and Training (TVET) engineering students' generic skills: problem solving; critical thinking; communication; and life-long learning; and to assure the quality of Technical Vocational Education and Training (TVET) institution respectively.

3. Discussion: Components of PBL – Brief Overview of Different Learning Approach

3.1. Active Learning

Active learning is contrasted to the traditional way of learning where students passively receive information from the instructor. It is generally defined as any instructional method that engages students in the learning process (Prince, 2004). Drake (2012) agreed with Prince but added that the students need to be responsible for their own learning. While Felder and Brent (2009) defined active learning as "anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes" (p. 2). The most commonly cited definition of active learning comes from Bonwell and Eisen (1991) "Involving students in doing things and thinking about what they are doing" (p. 2). And we may have heard - "Tell me and I forget. Show me and I may remember. Involve me and I will understand" (Confucius, c.500BC). Though it is just a simple statement, it makes complete sense from the learning and teaching perspectives.

Different methods of active learning that most frequently discussed in the engineering literature are collaborative learning, cooperative learning, Conceive-Design-Implement-Operate (CDIO), Experiential Learning Theory (ELT) and Problem-Based Learning (PBL). Collaborative learning may refer to any instructional method in which the students at various performance level work together in small groups towards a common goal (Gokhale, 1995). As such collaborative learning can be viewed as encompassing all group-based instructional methods, including cooperative learning (Prince, 2004). Prince also added, some authors distinguish collaborative and cooperative learning as the collaborative learning is the emphasis on students' interaction rather than on learning as a solitary activity.

Cooperative learning is defined as a structured form of group work where students pursue common goals while being assessed individually (Panitz, 1996; Prince, 2004). Unlike less structured forms of collaborative learning, cooperative learning requires students to be individually responsible for their own learning. Therefore the teacher or facilitator need to carefully design the learning activities and regularly monitored as Smith, Sheppard, Johnson, and Johnson (2005) quoted "engaging students in learning is principally the responsibility of the teacher" (p. 2).

Another method of active learning is the CDIO. In the late 1990s, CDIO concept was originally conceived at the Massachusetts Institute of Technology. CDIO provides the students with engineering fundamentals set in context of conceiving – designing – implementing – operating industrial systems, industrial equipment and products (Crawley, Malmqvist, Ostlund, & Brodeur, 2007). Crawley et al. (2007) listed three overall goals for CDIO, which are the students, should be able to:

- Master a deeper working knowledge of technical fundamentals.
- Lead in the creation and operation of new products, processes, and systems.
- Understand the importance and strategic impact of research and technological development in the society (p. 2).

Experiential Learning Theory (ELT) has been introduced and widely used in human learning and development. The theory is called "experiential" is its intellectual origins in the experiential works of Dewey, Lewin, and Piaget. Taken together, Dewey's philosophical pragmatism, Lewin's social psychology, and Piaget's cognitive-developmental genetic epistemology form a unique perspective on learning and development (David A Kolb, Boyatzis, & Mainemelis, 2001; David A. Kolb, 1984).

3.1.1. Problem-Based Learning (PBL)

PBL approach is common in medical institutions. The approach was also largely conceived and developed in the academy, initially for training lawyers and clinical practitioners and subsequently adopted for other professional courses (Savin-Baden, 2000). Nevertheless, it is just as appropriate for technical vocational subjects, including family and consumer sciences, and traditional academic subjects (Ward & Lee, 2002). The rationale behind the statement is, in Technical Vocational Education and Training (TVET) the students need to master the hands-on skills and not so much on critical thinking skills as training lawyers and clinical practitioners. Therefore, there will be a difference of PBL implementation and assessment approach in Technical Vocational Education and Training (TVET) as compared to medical where PBL originated.

PBL is an innovative approach to learning that teaches a multitude of strategies critical for success in the twenty-first century (Bell, 2010). She also added through the problems, students gain knowledge from group discussions and asking questions that have piqued their natural curiosity to learn (p. 39). Savin-Baden (2000) defined PBL as an approach to learn through which many students have been enabled to understand their own situations and frameworks so that they are able to perceive, how they learn, and how they see themselves as future professionals (p. 2). In PBL, teachers act as facilitators, moderators or advisors (Ward & Lee, 2002) to oversee each step of the process, give feedback and approve each choice before student embarks on a direction (Savin-Baden, 2000). This will help the students to develop self-reliance and life-long learning in them.

The main goals of PBL are to help the students develop their generics skills such as flexible knowledge, effective problem-solving skills, self-directed learning, effective collaboration skills and intrinsic motivation (Hmelo-Silver, 2004; Tchudi & Lafer, 1996). In PBL environment, the contents are transformed into ill-structured problems to provide more realistic approach to learning and to create an educational methodology which emphasizes real world challenges, higher order thinking skills, multi-disciplinary learning, independent learning, teamwork and communication skills which motivate students to prolong lifelong learning (Paul, 2010).

Boud and Feletti (1998) considered PBL as one of the most influential of the last decades and defined it as a carefully planned curriculum, which is entirely based on solving practical problems and practical cases. According to Meier, Hovde, and Meier (1996), students taught within the lecture-based disciplinary system typically have not been able to solve problems that require them to make connections and use relationship between concept and content. While in interdisciplinary teaching, it starts with a topic, theme, problem, or project that requires active student engagement and knowledge of multi-disciplines in order to reach the learning outcome. In PBL (Savin-Baden, 2000) concerned that, the focus in organizing the curricular content is around problem scenarios rather than subjects or disciplines (p. 3). Because PBL is often interdisciplinary in nature, teacher need to recognize the connections between discipline and collaborate with other teachers in developing learning experiences that provide relevant application of contents and skills (Meier et al., 1996; Ward & Lee, 2002).

However, Prince (2004) argued, based on the literature, faculty adopting PBL are unlikely to see improvement in student test scores, but are likely to positively influence student on attitudes and habits in learning independently. This is the strength in PBL. The learning uses relevant applications that motivate students to search for a need of facts and not being dependent on the teacher. Masek and Yamin (2010) described PBL as one of the methods which resulted to Student Centred Learning (SCL) (p. 10). This method encourages students to solve relevant problems within groups and classes using the prior knowledge and available resources.

Prince (2004) suggested that the engineering faculty should be strongly encouraged to look at the literature on active learning because some of the evidence for active learning is compelling and should stimulate faculty to think about teaching and learning in non-traditional ways (p. 3). Ozbicakci, Bilik, and Intepeler (2012) concerned in order to create a student-centred approach through PBL also requires faculty to give up traditional ways of instruction and places the responsibility for learning squarely on student (p. 79).

3.2. Assessment in PBL

The essential feature of a teaching system designed to emulate professional practice is that the crucial assessments should be performance-based, holistic, allowing plenty of scope for students to make their own decisions and solutions (Biggs, 2003). Generic skills assessment in engineering is a major challenge in PBL (Zulkifli Mohd Nopiah, 2009). Prince (2004) added skills in problem solving and life-long learning are difficult to measure which resulted in data are less frequently available for these outcomes than for standard measure of academic achievement (p. 2).

Agreeing on what is to test and what is to focus is a matter of much debate. Assessment in PBL requires as much care and consideration as it is under other approach to learning and teaching. The consequence of this is that, if lecturers retain the assessment methods they use in their traditional curriculum approaches, the outcome can be a misalignment between their objectives and student learning outcomes (Mcdonald, 2005; Ozbicakci et al., 2012). Macdonald and Savin-Baden (2004) have a set of principles to guide in assessing students in enquiry and Problem-Based Learning. In most of the guidelines highlighted, the assessment should simulate what the professional does in their practice and ideally be based on a practice context in which students will find themselves in the future (p. 6). Mcdonald (2005) agreed and added assessment should also be moved beyond factual recollection to the application of knowledge and skills towards increasingly complex situations, involving a range of intellectual and practical activities in a variety of contexts. One of the approaches to ensure and assess the alignment of assessment methods with the learning outcomes is to use Bloom's taxonomy of cognitive domains (Jideani & Jideani, 2012). It is well-defined and broadly accepted tool for categorizing types of thinking into different levels: knowledge, comprehension, application, analysis, synthesis, and evaluation (Crowe, Dirks, & Wenderoth, 2008).

In order to analyse perceptions of the depth of understanding that students acquire, the lecturer must not discriminate students and should assess fairly with strong justifications, in other words being objective. In some cases reported by Bollela, Gabarra, da Costa, and Lima (2009) research outcomes mentioned the reluctance of the lecturer to award high marks to the student because of student's immaturity and sincerity. Since the human perceptions and assessment is very subjective, it is also happens during the peer- and self-assessments among the students. Reflection or peer assessment and self-assessment requires students to reflect and evaluate their own participation, learning progress, and products of autonomous learning (Hart, 1994). They evaluate not only their learning, but also the success of their social interactions (Bell, 2010). Papinczak, Young, and Groves (2007) mentioned in their research that performance of their peers is better compared to their own performance (p. 122). The studies have confirmed that self-assessment of process is not an accurate measure compared to their peers.

There are several methods used previously to measure student skills, performance and progress. One potential assessment has been developed by Novak (1990) was Concept Mapping (CM) at Cornell University. CM is the metacognitive tool that was developed for the study to show changes in learning. Another appropriate assessment found by Gallagher, Sher, Stepien, and Workman (1995) using a lab notebook as the problem log to record ideas, plans, strategies and progress. It assessed the record of a students' thinking process and documented student participation. The common practice in PBL assessment is students prepare a portfolio for assessment that includes notes, commentaries and articles they have read, and discussions of the evolution of their ideas to formulate and report their findings and conclusion (Tai & Yeuen, 2007; Tchudi & Lafer, 1996; Ward & Lee, 2002).

Another potential assessment is the authentic assessment and rubrics that were used in high school family and consumer nutrition class (Ward, 1998; Ward & Lee, 2002). Authentic assessment is utilized as students were evaluated using appropriate rubrics. Authentic assessment are categorised into performance assessment, portfolio assessment and self-assessment (Hart, 1994; Tai & Yeuen, 2007). Boden and Gray (2007) also noted in their research, The Department of Aerospace at the United States Naval Academy (USNA) via CDIO syllabus have used rating scales (rubrics) for evaluating student performance in the form of journals of student reflections, portfolio of student work over time, capstone project, and during oral presentations, in-class discussions and technical reports (p. 119).

Bollela et al. (2009) concerned the major challenges when implementing PBL is the use of appropriate strategies to assess formative generic skills assessment of the students (p. 2). The existing substantial variation in the assessment of the PBL process is largely confined to formative purposes only. However, Knight (2001) notes in his research, assessment for summative purposes is viewed as being of such high stakes that those being assessed see it as being in their own interests to emphasise what they know or can do - however limited or poorly - and to cover up as much as possible what they do not know or cannot do. Upadhyay, Bhandary, and Ghimire (2011) recommended, in setting up the summative assessment of the PBL, the curriculum needs to be designed in an innovative way, adopting various strategies to foster such skills and behaviours and incorporating the measurement into the assessment (p. 1151).

Assessing "what works" requires looking at a broad range of learning outcomes, interpreting data carefully, quantifying the magnitude of any reported improvement and having some idea of what constitutes a "significant" improvement (Prince, 2004). No matter how data is presented, there is always the issue of interpretation, although it is helpful to look at both statistical measures. It is hard to develop questions that will measure creativity, critical thinking and generic skills. Tchudi and Lafer (1996); Ward and Lee (2002) describe assessment in PBL as a game that engages the student in guessing what teacher wants rather than demonstrating the best they can do. They even suggested if PBL changes the game and learning is to be seen as relevant to life, new methods are needed for the teacher to be able to assess student progress.

According to Joy and Kolb (2009), there is an impact of culture in learning style scales and in deciding a persons' preference for abstract conceptualization versus concrete experience. Reliability and validity of the generic skills assessment need to be designed personally based on the disciplines and cultures. If it is not to be considered, the consequences might turn out as reported in The Australian in Higher Education segment on the 16th March 2012, an interim evaluation of the Assessment of Higher Education and Learning Outcomes, or AHELO, has done the feasibility study on the US generic Collegiate Learning Assessment (CLA) test and found that it was hard to judge whether a generic skills assessment that was not linked to discipline content and different cultures, can be valid and reliable.

4. Conclusion

Based on the literature that has been reviewed, it will challenge the PBL assessment design to be more measurable and reliable especially in generic skills from Technical Vocational Education and Training (TVET) in engineering perspective. The aspects of inter disciplines, different cultures and education system policies need to be considered when designing the generic skills assessment. Globalization and rapid changes in technology must also be taken into account. As TVET students are expected to master the hands-on skills and not so much on the critical thinking, there will be a difference in PBL implementation and method of assessment.

This research will be using an inductive approach, where it will begin with PBL assessment observation and measures. Then detect the generic skills patterns and current assessment methods to measure the skills, formulate the tentative hypothesis and finally end up developing some general conclusions or theories. Details of the research methodological will be written in the future paper.

By determining the effectiveness of the students generic skills, the institute/university and Ministry of Education would be able to bring about curriculum change to help the students develop better skills. The author supports this with the claim that the development of quality, valid and reliable assessment method, and the engagement in actual assessment help to improve students and institute/university performance.

5. Tables

Table 1. Comparison of Generic Competencies

Australia	**United Kingdom (NCVQ)**	**United States (SCANS)**	**New Zealand**
Key competencies	Core skills	Workplace know-how	Essential skills
Collecting, analysing and organising information	Communication	Information Foundation skills: basic skills	Information skills
Communicating ideas and information	Communicating Personal skills: Improving own learning and performance	Resources Foundation skills: basic skills	Communication skills
Planning and organising activities	Personal skills: Improving own learning and performance	Resources Foundation skills: personal qualities	Self-management skills Work and study skills
Working with others and in teams	Personal skills: working with others	Interpersonal skills	Social skills Work and study skills
Using mathematical ideas & techniques	Numeric: application of numbers	Foundation skills: basic skills	Numeric skills
Solving problems	Problem-solving	Foundation skills: thinking	Problem-solving and decision-making skills
Using technology	Information technology	Technology Systems	Information skills Communication skills

Source: (Moy, 1999)

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