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Harnessing Technological-Creativity for Economic Development: A Problem-Oriented Project-Based Learning Approach

[1]Ruhizan M. Yasin, [1]Saemah Rahman, [2]Kamaruzaman Jusoff, [1]Melor Mohd Yunus and [1]Asnul Dahar Minghat

[1]Faculty of Education, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[2]Faculty of Forestry, Universiti Putra Malaysia, 43400 Selangor, Malaysia

Abstract: Literatures on the student-centred approach of problem-based learning (PBL) and problem-oriented project-based learning (POPBL) have documented their positive effect on having meaningful learning. Skills like Self-directed learning and other life-long learning skills which are among the requirements of the workers today and the future. In addition, to sustain in competitive globalized new economy era, a nation needs to have a pool of creative, innovative, critical and analytical human resources. The main objective of the paper is to analyse the environment for harnessing Technological Creativity (T-Creativity) through POPBL approaches practiced in Malaysian polytechnics. Furthermore, the study also identified the issues and challenges faced by the lecturers using an open-ended questionnaire. The T-Creativity elements were assessed using the survey method. The questionnaire was distributed to 183 lecturers from 12 selected polytechnics. The data were analysed using percentage and mean. T-Creativity environment appeared to be present in the teaching approaches used. With regard to the challenges faced, the qualitative results revealed that, some issues and challenges such as students' ability, teachers' training and infrastructures need a serious attention from the management. These implied that to fully promote T-Creativity, the teaching and learning environment such as having an innovative instructional approach as POPBL and students' motivation needs to be seriously addressed in designing a curriculum.

Key words: Problem-Oriented Project-Based Learning · Technological-Creativity · Engineering Education Curriculum · Life-long Learning

INTRODUCTION

Malaysia presently considered as a developing country, has progressed very steadily from an under-developed agricultural country to a semi-industrialized developing country since the 1990s [1]. In the first quarter of 2010 Malaysia has showed its fastest quarterly growth in 10 years of gross national product (GNP) of 10.1 percent [2]. To be like many other world most developed countries, Malaysia has mapped its vision of becoming a fully industrialised country by the year 2020 coupling with the New Economic Model of becoming a high income economy in only less than 10 years from now. Therefore, in order to at least sustain at such economic growth, our effort should be redoubled as the current Prime Minister envisioned 'For Malaysia to be a high-income nation, we must be able to compete on a regional and global stage. This requires redoubling our effort to attract investment, drive productivity and innovation. The foundation of any productive high-income economy lies in a globally competitive, creative and innovative workforce. To achieve this, an integrated approach to nurturing, attracting and retaining a first-world talent base will be implemented. The creativity, energy and initiative of the private sector will be harnessed as the primary driver of Malaysia's growth aspirations' [2]. With the globalized and competitive climate Malaysia must be more aggressive in charting its strategies especially in terms of producing more innovative and creative human capital because in terms of productivity, currently Malaysia is still way behind its Asian counterparts such as China, Singapore and Korea. Developed countries such as Germany, Britain, America and Australia have long been advancing with their technological capability and creativity as a catalyst for their economic advancement and prosperity [3, 5].

Corresponding Author: Ruhizan M. Yasin, Faculty of Education, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia. E-mail: dr_ruhizan@yahoo.com

Technological Creativity (T-Creativity): Technology is defined not only as modern 'engineering' or 'applied science' but also referred as 'manual craft work' [6] which includes tools, systems and processes that enhanced human capability [7]. Technological Creativity (T-Creativity) is an innovation and invention generated and very much accounted for economic growth which is measured by patents obtained [1, 3, 5]. Usually most were in the realm of machineries and involved engineering and design [8]. In the last several decades, many of the world's most developed countries have shifted from an industrial economy to a knowledge economy, that is based on the creation of knowledge, information and innovation. Educational researchers have paid very little scholarly attention to this economic shift, although it has substantial implications [9, 10]. In today's knowledge society, creativity always occurs in complex collaborative and organizational settings. Creativity is the core of a knowledge society, then the key task for educators is to prepare learners to be capable of participating creatively in an innovation economy. The focus of education should be given to more innovative teaching and learning strategies.

Malaysian Higher Education Scenario: Malaysian higher learning institutions are now facing the demand and challenges in producing competitive graduates who can perform work in complex situations. Flexibility and the ability to adapt and transfer the knowledge are critical in this knowledge-economy (k-economy) and Innovation-economy world. In addition, critical thinking skills, effective communication and problem solving are also known as the life-long learning skills required of Malaysian graduates to be sustained and prosper in the world of work [11]. The traditional approach in teaching where lecturers just give a lecture and have the students to memorise concepts and theories is no longer relevant. A more flexible and constructive approach which enables students to innovatively and creatively transfer their knowledge into real world situations is timely in today's higher learning environment.

Efforts towards realizing the lofty goal are aided by the Ministry of Higher Education's Framework named the 'Malaysian Qualification Framework'(MQF). In this framework there are eight learning outcomes every institution of higher learning should considered when developing a curriculum. The eight competencies are content knowledge, psychomotor/practical/technical skills, professionalism/values/attitudes/ethics, social skills & responsibility, life-long learning & information management, communication & team skills, critical thinking & scientific approach and managerial & entrepreneurial skills.

No doubt that the Malaysian Ministry of Education has taken the initiative in inculcating critical and creative thinking in the national education curriculum through the embedded approach, but the effectiveness of this effort is still questionable. Several researches on the efforts indicated that the approaches are not successfully implemented owing to the examination oriented system in schools [11, 12]. Therefore, it is urgent to find out how we could promote T-Creativity among young Malaysians in other alternative ways especially at tertiary level such as polytechnics.

Planning is an important part in the implementation of any programme because it will determine the success or failure of the programme. Educational planning has to be evidence based in order to fulfill the contextual needs. The Malaysian Polytechnics System is the post-secondary institution which trains skilled and semi-skilled workers for the country. According to the research done by the polytechnic's management, most of the graduates of polytechnics will further their study to higher learning institutions or end up working [13].

Creativity is considered as a critical skill in lifelong learning, as well as a skill needed in scientific problem solving and entrepreneurship. I argued that T-Creativity could be harnessed using the innovative approach of problem-oriented project-based learning (POPBL). However we have to first understand how to nurture creativity in our context of the engineering education programme offered by the polytechnics system. Thus, it is critical to study how T-Creativity can be implemented through innovative teaching and learning such as problem-oriented and project-based learning (POPBL) in engineering education at Malaysian polytechnics. To what extent does a T-Creativity environment exist in the teaching and learning in the current practices of POPBL as perceived by the lecturers? Consequently, what are the issues and challenges faced in implementing such innovative pedagogy?.

Problem-Oriented Project-Based Learning (POPBL): POPBL not only focuses on getting solutions to interested social issues but also on promoting students' creativity [14]. Having this experience, students could enrich themselves with the knowledge they discovered. It is a more student-centred approach which does not require students to memorise theory or formula, instead, they are required to have a more analytical and creative way of thinking by analysing information gathered to solve the problem.

This pragmatic approach is concentrating more on the process rather than the content same as PBL [15]. The challenge in implementing Problem Based Learning (PBL) is '... In problem-based learning, the focus is on organizing the curricular content around problem scenarios rather than subjects or disciplines. They are expected to engage with the complex scenario presented to them and decide what information they need to learn and what skills they need to gain in order to manage the situation effectively' [16]. The objective of the research is to determine polytechnics lecturers' perception towards the T-Creativity environment accounted by POPBL and the issues and challenges pertaining to its implementation at the Malaysian polytechnics.

MATERIALS AND METHODS

Research Design: The study was divided into two parts which were quantitative and qualitative approaches. The quantitative part was a survey on lecturers' perspective on some environmental elements for T-Creativity which also dimensions for POPBL. The elements were self-regulated learning, group learning, psychological motivation, lecturers as facilitators, ill-structured problems and real-world problem, Lifelong learning and continuous and alternative assessment. The qualitative part was open-ended questions regarding problems and challenges faced by the lecturers in their teaching and learning.

Participants and Procedures: There are twenty polytechnics in Malaysia with more than 80,000 students' enrollment. The study was conducted at 12 polytechnics and the focus was only on the engineering programmes. A total of 183 lecturers have participated in the study for the quantitative part. Out of 183 respondents, 182 (99.5%) had answered the open-ended questions.

Statistical Procedures: The data was analysed using descriptive statistics (percentage and mean) for the quantitative data while the qualitative data was analysed using thematic analysis.

RESULTS AND DISCUSSION

Table 1 and Table 2 shows the percentage of respondents by department and gender. The majority of the respondents were from the three main engineering departments (electrical, civil and mechanical). There was also a small number of respondents teaching the engineering programme but who are from the ICT and sports and recreation department. ICT and sports are two general education subjects which are mandatory for all engineering students. Among the respondents, 88 (48.1%) are male and 95(51.9%) are female.

Table 1: Department of Respondents

Department	Frequency	Percentage
Civil Engineering	60	32.80
Electrical Engineering	67	36.60
Mechanical Engineering	49	26.80
ICT	6	3.30
Sport and Recreation	1	0.50
Total	183	100.00

Table 2: Gender of Respondents

Gender	Frequency	Percentage
Male	88	48.10
Female	95	51.90
Total	183	100.00

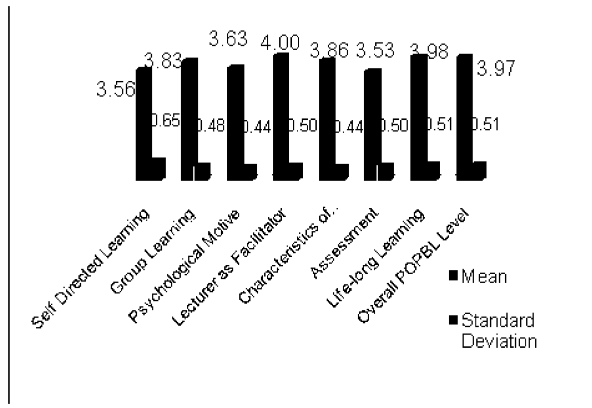

Fig. 1: Graph of Mean and Standard Deviation of Lecturers Overall Perception of T-Creativity Elements in the POPBL Approach.

Lecturers' Perceptions of the Environment for T-Creativity: Fig. 1 shows the overall means of lecturers' perceptions of T-Creativity environmental elements. A mean of 3.70 and above is considered high in terms of lecturers' views on the elements. The dimension of PBL and POPBL which received lecturers' highest rating was 'lecturers' role as facilitator" (mean = 4.00), while the dimensions of 'assessment' and 'self-directed learning' were among the lower ratings with mean's of 3.53 and 3.56 respectively.

Table 3 shows items on assessment dimension. Assessment dimension in POPBL should have continuous and alternative assessments like process evaluation, peer evaluation and self-evaluation.

Table 3: Mean and Level of Each Item in Assessment Dimension

Assessment	Mean	Level
1. In this programme, students' assignments are assessed by programme lecturers only.	3.79	High
2. In this programme, students' assignments are assessed by other lecturers.	3.11	Moderate
3. In this programme, students are actively involved in assessing their group members.	3.45	Moderate
4. In this programme, assignments are assessed through individual presentations.	3.62	Moderate
5. In this programme, assignments are assessed through group presentations.	3.92	High
6. In this programme, students are assessed during group discussions.	3.72	High
7. In this programme, students are assessed by peer group in the process of solving problems.	3.19	Moderate
8. In this programme, students are assessed continuously in project implementation.	3.87	High
9. In this programme, students are assessed only through the end product (project).	3.06	Moderate

Table 4: Mean and Level of Each Item in Self- Regulated Dimension

Self-Regulated Learning	Mean	Level
1. The programme allows for self-directed Learning.	3.67	Moderate
2. The programme allows students to determine their own learning.	3.39	Moderate
3. The programme allows students to determine their learning needs.	3.65	Moderate
4. The programme allows students to search online learning materials.	3.69	Moderate
5. The programme is made easy through online searches for learning materials.	3.70	High
6. The programme is designed for online Learning.	3.44	Moderate
7. The programme allows students to do assignments with minimal lecturers' assistance.	3.47	Moderate
8. The programme allows students to be more independent in solving problems.	3.49	Moderate
9. The problem allows students to relate learning problems with personal experience.	3.46	Moderate
10. The programme allows students to integrate all past learning with problems to solve in the assignment.	3.63	Moderate

Table 5: Means and Level of Lecturers' Perception on Nature of Problems

Items	Mean	Level
1.In this programme, problems to be solved are from real world problems.	3.91	High
2.In this programme, problems to be solved are mostly ill structured.	3.53	Moderate
3.In this programme, problems to be solved need specific knowledge.	3.92	High
4.In this programme, problems to be solved are multidisciplinary.	3.86	High
5.In this programme, through problem solving new knowledge and experience can be gained.	4.07	High
6.In this programme, problem solving helped to increase student's problem solving skillss	4.10	High
7. In this programme, problem solving needs students to get information through ICT	4.01	High
8. In this programme, materials from the web support students' learning.	4.02	High
9. In this programme, self-solving activities help to develop student's verbal communication.	3.92	High
10. In this programme, self-solving activities help to develop student's writing skills.	3.93	High
11. In this programme, self-solving activities help to develop students' visual communication.	3.99	High
12. In this programme, problems need to be solved in groups.	3.91	High
13. In this programme, problems need to be solved individually.	3.46	Moderate
14. In this programme, problems need to be solved with community (industry) support.	3.65	Moderate
15. In this programme, the community (industry) is invited to give information in the process to complete assignments.	3.64	Moderate

Table 6: Qualitative answers by Lecturers on Problems and Challenges

Student	Lecturer	Facilities
• Big group	• Mastering of content knowledge	• Inconducive
• Low ability (slow learner)	• Need to increase creativity	• Insufficient space
• Not focused	• Industrial skills	• Lack of current technology
• Lack of creativity	• Easily get bored	
• Not active	• Not independent	
	• Professional development	
	• Patient and enthusiastic	
	• Lecturer-student relationship	

It reveals that the existing programmes still have the traditional approach in assessing students. The alternative approaches were not fully implemented. Lecturers were still the sole assessor for the students' performance. However students were assessed continuously through out the project implementation (mean=3.87).

Self-regulated Learning is an element one should have in order to be creative and innovative. The overall mean of 3.56 for self-regulated learning shows that the existing programme is not giving much space for students to explore and determine their learning. This can be seen in Table 4 where are majority of the items have means of a moderate level.

In the existing programme, students are required to complete a final project before graduating. Table 5 shows that most teachers rated the nature of problems given to students helped the students in many ways especially in the ability to solve problems. However the approach of exposing students to the outside and real world through community and industry involvement is still lacking. This aspect should be looked into in the future.

Lecturers Views on Problems and Challenges: The second part of the study was qualitative in nature with open-ended questions. The questions were around students' characteristics, lecturers' competence, knowledge and facilities. Table 6 shows the qualitative answers of the lecturers on those aspects. A majority of the lecturers thought that they had a very big group of students to handle. Besides that they were having problems with students' ability where in they thought the students took too much time to understand the subject matter. Lack of creativity, not active and more dependent on lecturers are also considered to be the problem faced by the lecturers.

As far as the facility is concerned, the lecturers thought that they did not have enough space for a very big group of students. This lack of space contributed to the inconduciveness of the classroom environment. Besides that, ICT facilities like computers and the Internet were neither enough nor up to date as reported in [17].

In order to implement POPBL, the lecturers see the challenges are to solve the above problems as well as to increase lecturers content knowledge and skills. To promote the creativity of the students, creative teachers are needed as well; where they thought as lacking. The elements discussed above can be achieved through professional development as well as exposure to industrial skills which are also deficient. To handle students with low ability and; lack of motivation and focus, the lecturers should be more patient and must try to improve the lecturer-students relationship.

CONCLUSION

The results of the study confirmed that, the existing engineering education programme at Malaysian polytechnics do have some climates for T-Creativity. The observed climates are: problem solving, cooperative learning approach, lecturers as facilitators, psychological motive, self-regulated learning and other life-long learning elements were majority at satisfactory or moderate level. Assessment was still the main issue in implementing innovative pedagogy as agreed by [18]. The standardized traditional assessment practiced might be because of the nature of the programme designed which is more inclined to lecturer-centred rather than student-centred. Assessmeent should be aligned with teaching and learning activities. More alternative assessments should be employed besides the traditional assessment to reduce the anxiety of exams that hinder students' efficacy for problem solving effort [19]. Both self-directed learning and cooperative learning environments should be enhanced to promote creativity among students. Lecturers should give more freedom to students to explore their own learning and construct their own meaning both cooperatively and collaboratively. The programme should give more attentions to the process of getting to the end in producing an innovative product rather than just concentrating on the knowing the facts. A creative product is not just composed of individual traits, but also of societal and environmental factors. It means that a creative product is not accomplished by the individual alone, but rather it is the product of the interaction of a stable cultural domain and is embedded in the social system [20]. A more explicit curriculum such as PBL and POPBL should be expanded in the effort of harnessing T-Creativity because creativity underpins design and problem solving especially in technology and engineering education [21].

It can also be concluded that lecturers need to be retrained continuously so that they are more confident to have innovative approaches in their programme. More exposure to industrial training could also help the lecturers to be more creative in handling their programme and students and more transformative learning might be observed [22, 23].

Engineering education is a paramount important type of education in providing the nation with innovative, creative and critical thinking human capitals which will contribute to the sustainability of the economy. To achieve this, a good and holistic programme of engineering education at the post secondary level should be designed. Furthermore, the programme should also be able to transform the students' knowledge and skills into their practices as well as becoming more techno-preneur. The integration of entrepreneurship elements into the programme will help higher learning institutions to become as entrepreneurial enterprises [24, 25]. This is in line with getting the nation sustains with robust economic progress. As [26] has stated 'creativity is more a cultivated ability than a natural one'. The climate of creativity should be enhanced beyond the classroom.

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