

INTEGRATED CURRICULUM APPROACH IN DEVELOPING 21ST CENTURY INDUSTRY-READY GRADUATES

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ABSTRACT

The experiences in designing an integrated curriculum for the Bachelor in Civil Engineering Technology (BCT) programme is presented in this paper. The programme currently being offered in Politeknik Ungku Omar is adapting the innovative engineering education framework of Conceive-Design-Implement-Operate (CDIO) real-world systems with the objective to produce a new generation of engineering technologists. Precisely, the curriculum was designed using CDIO Standard 3 – Integrated Curriculum and CDIO Standard 7 - Integrated Learning Experiences focusing on providing integrated learning experiences for students to take an active role in their learning process. The 40-week structured on-the-job training or Work-based Learning (WBL) with partnership from the nation's key-industry players and construction companies were discussed. The industry collaboration and partnership aim to provide a real-life work environment and facilitate structured and experiential learning for Year 4 students before graduation and eventually join the workforce. The paper concludes with an evaluation of the efficacy of the integrated curriculum measured through feedback received from the industry partners on students' performance in the WBL and the graduate employment rate. Graduate employment has significantly improved and BCT graduates are well accepted by the industries. The graduate has been recognized to be more industry-ready and confident in facing challenges in the construction industry. However, the interaction with recent graduates and industry partners indicates that there are still gaps in BCT graduates' skill sets and actions to address these gaps are discussed.

KEYWORDS

Integrated curriculum, work-based learning, Standards 3, 7

INTRODUCTION

The Construction Industry Transformation Programme (CITP) 2016-2020 is a Malaysia national agenda that aims to transform the construction industry to be highly productive, environmentally sustainable with globally competitive players without neglecting on safety and quality standards. One of the strategic thrusts in CITP is 'Productivity', the primary engine of growth towards Malaysia's high-income targeted in the 11th Malaysia Plan. Among the initiatives included in CITP were to accelerate the adoption of Industrialized Building Systems (IBS) mechanization and modern practices and to roll out technology advantage across project life cycle by facilitating Building Information Modelling (BIM) adoption in construction industry via regulations. The civil engineering sub-sector is expected to remain as the driver of the

construction sector in Malaysia to spearhead the 11th Malaysia Plan. This is supported by expansions in high impact infrastructure projects such as in rail links and transit lines, airports, roads and highways as well as the new planned supply in the affordable homes and industrial segments, making the demand for industry-ready workforce is set to grow in the construction sector (Ministry of Finance Report, 2019/2019).

In response to this, the Bachelor in Civil Engineering Technology (BCT) curriculum at Politeknik Ungku Omar (PUO) were revised in 2015 focusing on new technologies and modern practices namely Information Technology (IT) Construction via Building Information Modelling (BIM), risk assessments and quality management in construction sector. These technologies and practices were integrated with personal skills, interpersonal skills, teamwork and communication, product, process, and system building skills to prepare graduates for the 21st century challenges. Additionally, the innovative engineering education framework of Conceive-Design-Implement-Operate (CDIO) principles and guidelines were also adapted into the revised curriculum (Crowley, Malmqvist, Ostlund & Brodeur, 2007). The CDIO Standard 3 – Integrated Curriculum was adapted in this curriculum to better reflect the multidisciplinary nature of Civil Engineering Technology. Other than that, the CDIO Standard 7 - Integrated Learning Experiences, focusing on providing an integrated learning experience, active learning and self-discovery for future career needs were also applied.

METHODOLOGY

Integrated Curriculum Design

A need analysis was carried out to the current construction industry landscape and workforce needs in Malaysia through a survey with BCT alumni. The interviews with leading construction associations nationwide, Master Builders Association Malaysia (MBAM) and the government agency that regulates the construction industry, Construction Industrial Development Board (CIDB) were also conducted. The outcomes of the need analysis are summarized as follows:

- Feedback from MBAM indicates that the current BCT curriculum remained relevant to the construction industry for skill sets in the areas of infrastructure planning, designing and constructing. Nevertheless, skill sets that support the latest technology in IT Construction, risk assessments and quality management as well as personal and interpersonal skills are suggested to be further enhanced into the curriculum.
- Information gathered from CIDB pointed to the emerging workforce needs on skill sets to support the government push towards higher productivity using IT Construction and environmental sustainability in the construction industry.
- The BCT alumni responded that the current curriculum successfully equipped them with strong foundation knowledge and skills in infrastructure planning, designing and constructing. Nevertheless, employment in the construction sector seems to require different skill sets particularly on the latest construction technology, operation and maintenance, and quality compliance.

Integrated Curriculum

The CDIO Standard 3 – Integrated Curriculum (Figure 1) is the key strategy in designing this revised curriculum. It aims to mutually support the disciplinary courses with an explicit plan to

integrate personal, interpersonal, and product, process, and system building skills (Crawley et al., 2014). Currently, there is a global trend where employers placed higher emphasis on 21st century skills than technical skills as necessary attributes from their workforce (Reeve, 2016). Therefore, the curricula of higher learning must incorporate effective platforms, such as collaborative project-based learning, for students to develop and demonstrate these attributes (Zhou, 2012).

Following the design process recommended by Malmqvist, Ostlund and Edstrom (2006), the objective of the revised curriculum is to train a cohort of Civil Engineering Technology graduates to be technically competent, professionally proficient and socially responsible in planning, designing and constructing infrastructures as well as an advantage in acquiring competencies of new technologies and modern practices namely IT Construction via BIM, risk assessment and quality management in the construction sector. This is followed by an iterative process of developing the learning outcomes, aligning the learning outcomes, designing the learning activities and applying the assessment methods of the courses offered in this curriculum in an integrated manner to meet the construction sector's needs. The sample of revised curriculum designing process is shown in the diagram below.

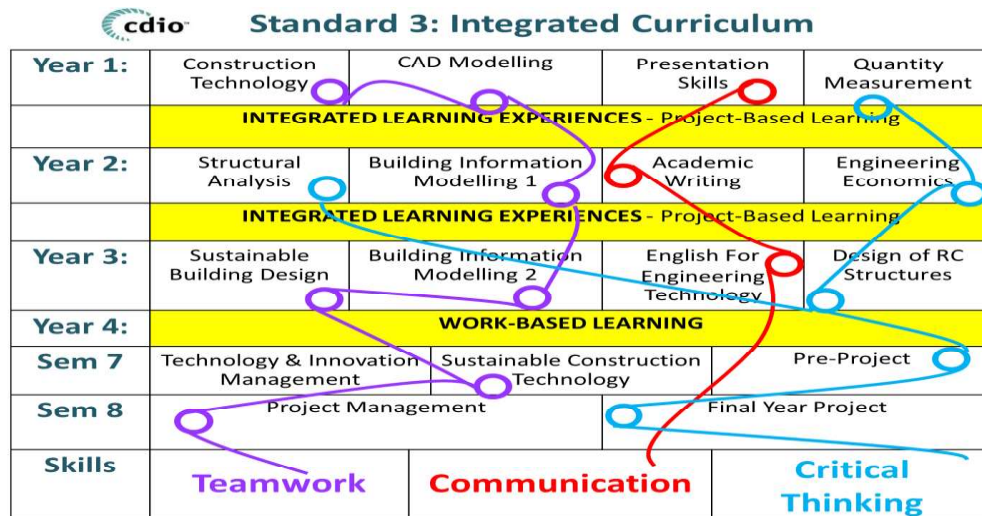


Figure 1. The Revised Integrated Curriculum Learning Track of the Bachelor in Civil Engineering Technology Programme (BCT)

Integrated Learning Experiences

The Intra-Programme Integrated Learning Experience (IP-ILE) is incorporated in BCT curriculum learning track. It is a collaborative project-oriented problem-based learning (POPBL) integrated into two or more technical courses (core-discipline) and a communication course (common core) within the same semester as shown in Table 1. The assessments are carried out on the process and the project outcomes for both individuals and group work. In general, the purpose of IP-ILE are as follows:

- i. To engage, enable and empower student's skills through multidisciplinary projects.

- ii. To deepen and diversify student skills, in both technical domains and project execution for 21st century skills, such as collaboration, communication, critical and creative thinking, and problem solving.
- iii. To enhance students' presentation and public speaking skills.
- iv. To inspire and encourage innovation culture whilst providing a risk-free environment.
- v. To give the students' opportunity to optimize their student learning time (SLT) effectively and be more focused to produce a better project.

Table 1: An Example of Integrated Learning Experiences and Experiential Learning (CDIO Standard 7) in PUO Collaborative Project-Oriented Problem-based Learning

APPROACH		CURRICULUM TRANSFORMATION	
Intra-Programme Integrated Learning Experiences			
Project LOs	Courses	Related CLOs	Assessments
<p>At the end of the project, students will be able to:</p> <p>1. Collaborate in a team and use parametric modelling (BIM) to construct a model and make the quantity measurement for building according to Standard Method of Measurement, Malaysian Standards, guidelines, regulations and practices.</p> <p>2. Present the building model effectively and confidently using appropriate presentation as well as language and non-verbal communication skills.</p> <p>3. Explain the technical aspects of the model clearly in a Q & A session.</p>	BCT 2043: Civil Engineering Construction Technology	<p>Synthesize technical skills on using parametric modelling in civil engineering construction technology. (C5, PLO2)</p> <p>Exhibit the ability to engage in independent and life-long learning to society commonly encountered in construction of civil engineering technology careers. (A5, PLO9)</p>	POPBL Project - 20%
	BCT 3073: Contract Procedure & Quantity Measurement	<p>Measure rate the building element by using Parametric Modelling in quantity measurement. (C5, PLO2)</p> <p>Develop good teamwork skills in quantity measurement. (A4, PLO12)</p>	PBL Project - 10%
	BUE 1013: Presentation Skills	Deliver informative and persuasive speech for specific purposes using appropriate language and relevant presentation skills. (C6, A5)	Presentation - 30%
	BCT 1033: CAD Modelling	Apply the principle of plane geometry and isometric drawing by using CAD software. (C4, PLO2)	POPBL Project - 35%

Work-based Learning

Work-based Learning (WBL) is a learning approach in which polytechnics and industries work together to conduct teaching and learning process (Boud, Solomon & Symes, 2001). This is a well-structured on-the-job training (OJT) programme developed together with BCT's industry partners to meet the training needs of an industry and to provide a real-life work environment. It has been designed as a structured internship programme with core discipline courses incorporated in the learning track for BCT Year 4 (Figure 1). Through the experiential learning, students can further deepen their competencies for occupational skills, transferable workplace skills and personal effectiveness skills. Students were able to carry out internships in several related project management practices within the construction projects and gained valuable experience on risk assessment and quality management in the construction industry. The WBL is implemented in the final year of the programme i.e. in the 7th and 8th semester, covering 20 weeks per semester (see Figure 1). In total, students will be attached to the industry for 40 weeks or equivalent to 1600 hours of OJT. At the same time there are three core discipline courses offered in the 7th semester; BCT7264 - Pre-Project, BCT7275 - Technology and Innovation Management and BCT7288 - Sustainable Construction Technology with a total of 17 credit hours. Meanwhile, in the 8th semester, two core discipline courses are offered: BCT8297 - Project Management and BCT83010 - Final Year Project totalled 17 credit hours.

PUO BCT programme collaborates with Master Builders Association Malaysia (MBAM) and its participating companies and Universiti Malaysia Pahang Holdings (UMPH) with its subsidiaries companies in implementing WBL since 2016. The WBL learning process in BCT context requires students to sit for several courses while undergoing the internship. These courses are monitored and assessed directly by lecturers of the polytechnic. Concurrently, students will be assessed by the industry mentors appointed for projects or work assigned at the workplace. Primarily, the industry mentors will supervise all practical work while student's academic achievement will be assessed by polytechnic lecturers at the workplace. Therefore, these students will be observed by polytechnic lecturers from time to time as scheduled in their learning process (Figure 2).

In facilitating the student learning process, PUO lecturers and industry mentors use learning activities, environment and assessments that align with the learning outcomes (Biggs, 2003). To assist the industry mentors, a team-teaching approach consisting of two or more lecturers teaching the same course are paired-up with the industry mentors (Buckley, 2000). The team-teaching from both PUO and industry able to share ideas to convey knowledge to the students. This can shape the value of teamwork among lecturers and industry mentors in delivering teaching and learning (T&L). The industry mentors oversee the practical aspects of the course whilst the theoretical aspects are led by the polytechnic lecturers. The team T&L can be in a blended learning format using e-Learning approach.

E-Learning refers to the use of information and communication technology to facilitate the process of T&L (Department of Higher Education, Ministry of Higher Education, 2011). A combination of 70:30 online learning mode and face-to-face of the course content is employed in this WBL T&L. In assessing the WBL, appointed lecturers will carry out an observation at the company premise scheduled by the PUO WBL coordinator. The continuous assessments, appraisal and feedback from the industry mentors will be gathered during this observation visit. Eventually, the result will be presented to the industry at the end of the WBL period. (Figure 2). The feedback and suggestions received is used to improve the future T&L process.



Session conducted by industry trainer



Supervision by visiting lecturers at the company site



Student skills application on site supervised by industry mentor



Visiting lecturers on site



Presentation of result for practice-oriented assessment to participating companies at the end of each cohort



Figure 2. BCT-WBL Teaching and Learning by the Industry and PUO

The diagram underneath summarised a complete circle of the PUO BCT- WBL teaching and learning.

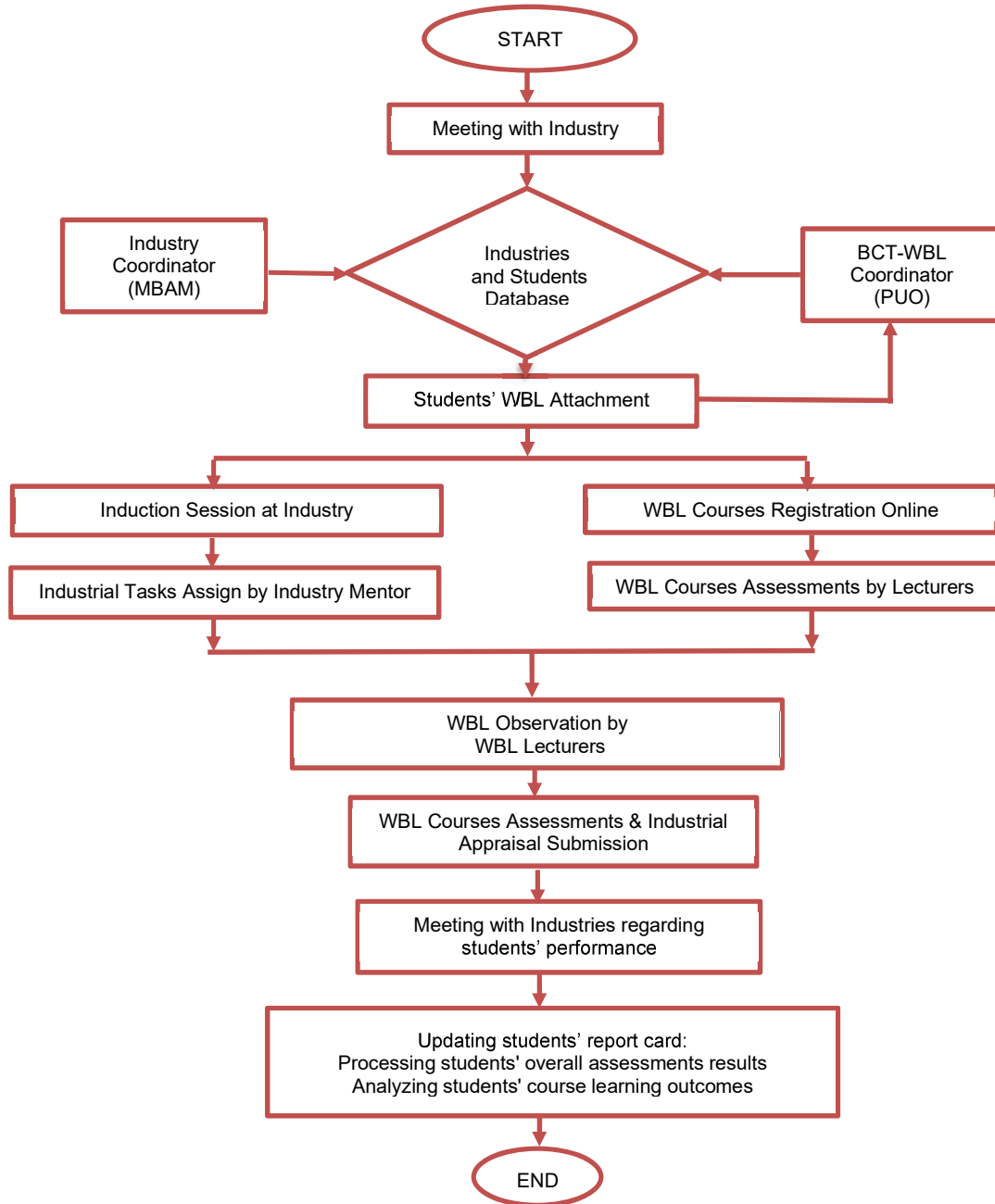


Figure 3. PUO BCT-WBL Implementation Flow Chart

RESULTS AND DISCUSSIONS

The collaboration between PUO and Malaysia leading construction industry has gained a positive impact on BCT graduates' employability. Total time spent at the workplace through WBL (40 weeks) enabled the students to be trained and exposed with real work environment.

Students become more competent in both technical and non-technical skills such as personal and inter-personal skills in communication, teamwork, leadership, critical thinking and problem solving. PUO WBL participating companies has given full commitment and they are basically satisfied with the graduates. Indeed, the first cohort of the graduates were fully employed immediately after their graduation. To date, the BCT programme has had produced 4 cohorts of graduates and all have an outstanding employment rate record. Graduates employability data collected annually by the Department of Polytechnic and Community College Education (DPCCE) during the graduation using TVET Tracer Study System - *Sistem Kajian Pengesanan Graduan-TVET* (SKPG TVET) recorded that almost all graduates has been employed either by the partners' company or other company in the same field locally and overseas, some became entrepreneurs, others pursue further studies and a few took a break for personal reasons. The BCT employability rates are summarized below:

Table 2. Graduate Employability for PUO BCT-WBL Graduates

Year / Cohort	Number of graduates	Work with Participating Companies	Work with Other Companies	Self Employed/ Entrepreneur	Further Study	%
February 2017 1 st Cohort	28	11	10	5	1	96
February 2018 2 nd Cohort	28	8	18	1	1	100
August 2018 3 rd Cohort	25	11	11	2	1	100
August 2019 4 th Cohort	30	Result still in progress				

The statistics show that the BCT graduates were immediately offered a job upon completing their WBL, with the longest waiting time of two months. For the first cohort, one of the graduates was unable to commence work immediately due to personal reasons, making up the employability rate of 96%. In the second cohort, there were three graduates who turned down the offer by participating companies and one was offered to work overseas. There are many reasons why these graduates turned down the offer by participating companies, for example the location of the project site, distance from family/hometown, salary offered by other competitors as well as pursuing further education. In addition to the tracer study conducted, a testimonial by employers were also gathered. The summary of the testimonial is depicted:

Table 3. Industry Testimonials of PUO BCT-WBL Graduates

No.	Testimonial	Organization and Position
1.	"PUO BCT-WBL programme has become a benchmark programme by universities in Malaysia. Under the wing of various mentors from the companies, the students were able to adopt the soft skills promisingly and received their training with open hearts. I am proud to say MBAM has no regrets working with PUO on this program and always welcome more activities in future. All the big public listed construction companies which participated in the program valued their employees who were PUO BCT-WBL graduates."	Tan Sri Sufri Mohd Zin, Deputy President of Master Builders Association Malaysia (MBAM) cum Group Managing Director of Trans Resources Corporation (TRC) Sdn. Bhd.

2.	"PUO BCT-WBL student do not requires another learning curve, they can immediately start work and able to catch up with site works as soon as possible. We indeed have no hesitations in hiring them immediately after their graduation"	Ir. Selvaraja Marappan, Project Manager of Sunway Construction Group Berhad.
3.	"The student is able to work with least supervision and very innovative. We have adopted the project designed by the student, "e-Borelog", an application that prepares bore log as a payment claim. The project is very helpful to us as it really saves us time and money as we move forward into a paperless society".	Ir. Shalom Morris, Senior Engineer of Bauer (Malaysia) Sdn. Bhd.

CONCLUSIONS

Since the launch of the revised curriculum for the Bachelor in Civil Engineering Technology programme in 2015, a total of 111 BCT students completed this WBL track in various job functions in the construction companies. The effectiveness of the integrated curriculum in this track was measured through the feedback received from the industry partners on students' performance in the WBL programme and the graduate employment rate. Positive comments were received from the industry partners on the students' performance. The industry mentors highlighted that BCT students demonstrated an excellent attitude in approaching the tasks assigned to them and had always given their best efforts to all tasks assigned. The students showed commendable initiatives in contributing new ideas and producing innovative solutions to problems encountered at the workplace via their Final Year Project. It was also highlighted that BCT students were competent in performing good project management practice which reflected their experience in conducting risk assessment and quality management in the construction industry.

Graduate employment survey showed an excellent result indicating industry recognition that BCT graduates are more industry-ready and confident in facing the complexity and challenges of the construction industry. However, through interaction with recent graduates and industry partners it shows that there are still gaps in BCT graduates' skill sets. They expressed that the students should be more resilient as working in the 3D (Dangerous, Dirty and Difficult) environment of the construction sector, requires them to have higher tolerance and to recover quickly from difficult work situations at the construction project site. In addressing these gaps, immediate action by PUO is by introducing an outbound camp activity for the upcoming cohorts. The activity is hoped to build students' flexibility and perseverance in the challenging situations as well as to apprehend their full potential through the tasks and challenges given during the camp's expedition.

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BIOGRAPHICAL INFORMATION

Yong Rashidah binti Mat Tuselim is a senior lecturer at the Civil Engineering Department, Politeknik Ungku Omar (PUO). She has been actively training and facilitating Malaysia Polytechnics' lecturers and students in the CDIO integrated curriculum framework and Design Thinking activities for social innovation projects and industries projects. Her current focus is on the continual improvement of Work-based Learning approach in Malaysia Polytechnics' Bachelor's Degree programs with the nation's industry players.

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Riam Chau Mai is the head of Corporate Industrial Services and Employability Centre of Politeknik Ungku Omar, Malaysia. Her expertise covers research on soft skills and skills related to student marketability of the institution beside the teaching work in accounting related subjects. Her task is to liaise the institutions with the community and industry locally and abroad. She is also a CDIO master trainer for the Department of Polytechnic and Community College Education Malaysia since 2015.

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