Work integrated learning: a realistic evaluation of KMUTT's chemical engineering practice school

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***Abstract**: ChEPS is a 2-year Masters program which is based on work-integrated-learning principles. The program produces chemical engineers possessing attributes industry requires through the integration of chemical engineering courses and real-life problems experienced through placement in industry. Since its inception in 1997, the program has produced nearly 260 graduates and over half of them are now working for leading companies in Thailand. In general, ChEPS graduates are highly sought after by industry. As part of a program review concentrating on student learning at placements, program effectiveness, and sustainability, Realistic Evaluation [Pawson & Tilley 1997, Realistic evaluation, Thousand Oaks, California: Sage] was used to evaluate the perspectives of key stakeholders: current students, alumni, university, placement sponsors, and subsequent employers. Through the RE framework, the paper illustrates how the placement contexts have impacts on program outcomes. An understanding of the contextual impacts could lead to a better understanding between the university and the placement, and the awareness of mentor teaching strategies.*

Introduction

Work integrated learning (WIL) and the chemical engineering practice school (ChEPS, KMUTT)

Work Integrated Learning (WIL) can be defined as a learning process that occurs through the connection between theory and practice; a WIL program is a program providing an opportunity for students to practice or be trained at industry placements (Cooper, Orrell, & Bowden, 2010). Based on a report on graduate employability (Precision Consultancy, 2007), WIL has been proposed as a mechanism to develop graduate attributes and employability skills in students since it can provide an opportunity for them to experience working in industries. So far, WIL programs have been operating across many areas including medicine, engineering, and business (Patrick, Peach, & Pocknee, 2009).

The Chemical Engineering Practice School (ChEPS) program was established in 1997 at King Mongkut's University of Technology Thonburi (KMUTT), Thailand. It was developed based on the School of Chemical Engineering Practice, MIT, USA (Johnston, Meadowcroft, Franz, & Hatton, 1994) which has been operating successfully for over 90 years. A major objective of the 2-year Master's degree program is to produce professional chemical engineers possessing attributes in strong technical knowledge, theory application, problem solving, team working, effective communication, time management, and English proficiency (Ku & Thonglek, 2011). These attributes are developed

through collaboration between KMUTT and industry. ChEPS students are provided with an opportunity to work at industry placements; therefore ChEPS can be categorised a WIL program.

Initially, ChEPS students spend one summer (10 weeks) revising undergraduate subjects. In the first year, they study advanced technical core courses (e.g. Mathematical Analysis for Chemical Engineering, Intermediate Chemical Engineering Thermodynamics, Chemical Reaction Engineering etc.) in a conventional classroom and also experience project-based learning. The projects are simplified real-life problems sponsored by industry. Through tackling the problems, students are expected to better understand theories and how the theories can be employed in the workplace, and to develop working skills that will be necessary during their placement.

In their 2nd year, the students spend one semester at the placement working in teams solving industry problems provided by placement engineers. Students work under the supervision of these engineers and a university staff member assigned to work full-time at the placement. Each placement accommodates 7-9 students; the academic significantly alleviates the engineers' workload by supervising the students for some technical issues. The academic also observes, reflects, and evaluates student learning. During the other semester, students conduct individual research either at a university or at the placement depending on research topics. To broaden the students' horizon, some students conduct their research overseas.

Ku and Thonglek (2011) reveal three key issues which ChEPS faces: student learning at placement, program effectiveness, and program sustainability. These issues are echoed in other literature. Kirby et al. (2003) focus on how to measure the learning outcomes developed in placements while Billett (2002) emphasises the importance of organisational context on student learning. However, even though Patrick et al. (2009) present various operational strategies for WIL programs, it seems that there is no documented evidence of a strategy that optimises effectiveness and sustainability.

Realistic evaluation

Traditionally, controlled experiments were conducted to identify and study the outcomes of educational programs. The differences between the experimental and control groups were attributed to the new teaching method (Campbell & Stanley, 1963). However, some limitations of this experimental approach have been found. Heywood (2005) demonstrates how the issue of unfairness could arise if the new teaching method has a positive effect on students. Practicality is another experimental problem. Heywood (2005) also explains difficulties in setting up experiments and interpreting data in fieldwork due to uncontrollable factors which then make evaluation difficult if not impossible.

In addition, the issue of research questions for the experimental design may also be problematic. Experiments are more likely to be designed to evaluate the program efficacy (Whether a program works or not.) than the program effectiveness (How a program work.) (Blackwood, O'Halloran, & Porter, 2010). Blamey and MacKenzie (2007) state that the evaluation of program effectiveness is difficult to achieve since the evaluation results not only reflect the program itself but also include the values and attitudes of the people involved in the program.

To overcome the above difficulties, a new approach for program evaluation called Realistic Evaluation (RE) was established (Pawson & Tilley, 1997). "*Ray Pawson and I are highly skeptical of this account of experimentation. We are doubtful of this as a method of finding out which programmes do and which do not produce intended and unintended consequences*" (Tilley, 2000). Shadish and Luellen (2004) also add that the experimental approach cannot fully address the issue of social program effectiveness which is highly contingent on people's value or attitude (Tilley, 2000). Rather than exploring whether the program works (the experimental approach), RE deeply investigates what (elements in the program) works for whom in which circumstances (Pawson & Tilley, 1997).

RE can be used to improve the program effectiveness (Pawson & Tilley, 1997). This framework reveals both expected and unexpected outcomes, and also the understanding of what in the program work or do not work for whom in which circumstances. As such, the understanding will provide us to be better able to adjust the program if the outcomes do not meet expectations.

Contexts are also to be considered as important factors of any evaluation including educational programs (Saunders, 1995). Thus, this paper employs the RE framework to investigate what happens to students at placements and how the placement context affects student outcomes. A framework of Realistic Evaluation (Pawson & Tilley, 1997) can be presented as follows:

Context (C) + Mechanism (M) = Outcome (O)

Where in this study:

Context (C):	program procedure, stakeholder's background and attitude
Mechanism (M):	what students do or decide to do which leads to outcomes in a given context
Outcome (O):	results of what students do

Data Collection Methods

Pawson and Tilley (1997) argue that RE emphasises quality of data not quantity. The framework investigates a set of ideas or patterns of outcomes embedded across groups of interests. In this investigation, 50 stakeholders of the ChEPS program were interviewed. The participant distribution including the interview timetable is presented in Table 1.

Table 1: Participant distribution and interview timetable

No. of Stakeholder		Interview Schedule													
		January 2011					February 2011								
Stakeholder	Total	25	26	27	30	31	1	2	3	8	11	14	15	16	22
University executive	2				1						1				
Academic Supervisor	9	4	2								2		1		
Current student	3									1	2				
Alumni	15			2		4	2	3	1				3		
Mentor	2						2								
Mentor (also alumni)	9			5		2		1	1						
Employer	5							3				1	1		
Employer at placement	4						1						1	1	1
Employer (also alumni)	1					1									

Open-ended interviews were conducted. The interviews can be either individual or in small groups agreed upon by the participant and the researcher. The duration of interview was 30 - 90 minutes. The questions were categorised into 3 themes: student learning outcomes, program operation, and program sustainability. Patterns of outcomes across different groups of stakeholders were explored. This paper presents how program stakeholders (university, placement, and student) perceive student outcomes and how the placement contexts (placement policy and industry mentors) affect such outcomes. The understanding of the effects of contexts may lead to a better understanding between the university and the placement, and the awareness of mentor teaching strategies.

Results

How program stakeholders perceive student outcomes

The student benefits are the underpinning drivers of the ChEPS program. At the beginning, the benefits which the stakeholders anticipated were investigated. Data were derived from the ChEPS operational procedure and stakeholder interviews. The data were analysed and presented in the form of context-mechanism-outcome configuration in Table 2.

In Table 2, the context (C_1-C_4) is the ChEPS procedure, the mechanism (M_1-M_4) is what students do, and the outcome (O_1-O_4) is what students gain. Student outcomes can be divided into 2 categories: learning outcomes, and employment benefits. The details of the outcomes are illustrated in Table 2. Table 2 shows both expected and unexpected outcomes. The expected outcomes (O_1,O_3) can be drawn from the ChEPS handbook and stakeholder interviews, whereas unexpected outcomes (O_2,O_4) are revealed through in-depth student interviews. A student said "*At (company), I observed how (name of his mentor) presented his work in a formal meeting and how he explained it (the work) to his*

colleague and operators. It's the same story but in different ways. I don't know how he could do that but I know this skill is very important". Another student added *"I talked to people in (company) but not technical stuff (smile). I need to know what a company wants from a graduate because I thought I had a problem with job interviews. Finally, I found out that job interviews might not be a big issue for me but I applied for the position not suited me.* (Prior to ChEPS, this student had a good academic performance in the undergraduate level but she tended to be declined after job interviews.) Both students agreed that they could not gain these invaluable experiences in the university.

Table 2: The CMO configuration of how program stakeholders perceive student outcomes

Context	Mechanism	Outcome
At university Academics organise teaching activities and material including the assessment (C_1) to prepare students prior to placement. *At placement* Academics (C_2) work with mentors (C_3) to prepare problems for students. Students (C_4) tackle the problems under the supervision of academics and engineers.	Mechanisms are the ways students decided to do at placement. For examples, students used different strategies to tackle problems such as: reading textbooks (M_1), discussing with their friends (M_2), academic advisors (M_3), and mentors (M_4).	*Expected learning outcomes (O_1):* - strong technical knowledge (O_{11}), - theory application (O_{12}), - problem solving (O_{13}), - team working (O_{14}), - effective communication (O_{15}), - time management (O_{16}), and - English proficiency (O_{17}) *Unexpected learning outcomes (O_2):* - knowledge acquisition (O_{21}) such as from colleague discussion and observation, - self-understanding (O_{22}), and - managing work under pressure (O_{23}) *Expected employment benefits (O_3):* - early job offer (O_{31}) *Unexpected employment benefits (O_4):* - confidence in job interviews (O_{41}), - understanding of organisational structure in workplace (O_{42}), and - appropriate job selection (O_{43})

According to Table 2, the unexpected outcomes lead to positive results to students which reinforce the concept of work integrated learning. However, it is generally accepted that what students will face at placements is unpredictable and organisational contexts also affect student learning (Billett, 2002). And thus, the next step, the study focuses on how the placement context has impacts on the student outcomes.

How placement contexts affect student outcomes

Based on the interviews, two components at placement have impacts on students: the placement policy, and the mentor attitude. The CMO configuration of the impacts of placement policy and the mentor attitude are illustrated in Tables 3 and 4.

The placement policy context

The policy of the ChEPS placements can be classified into 3 categories: supporting learning environment (C_5), searching for early recruitment (C_6), and expecting project outputs (C_7). How these different policies influence students is presented in Table 3.

One student said *"I think I was lucky since I worked in different placements. The first company, my mentor told me that, if possible, he wanted my project succeed but unless I could do that he was also fine at least we (my mentor and I) could learn something from it. He let me propose my thoughts (M_5) and tried it, definitely, under his supervision. I was happy about that (O_5) and finally, I could achieve the project goals. It differed from the second place; I was assigned to develop a simulation program that the company intended to use it with a plant unit. I was quite stressful that time. Again finally, I could make it. However, I had no idea what would happen if I couldn't achieve it."*

Table 3: The CMO configuration of how the placement policy affects student outcomes

Context	Mechanism	Outcome
Placement policy encourages a learning environment (C_5) or focuses on recruitment benefits (C_6).	Students feel free to learn both technical knowledge and people skills (M_5).	Students have a good impression on the placement (O_5) leading to good program reputation (O_6).
Placement policy focuses on project outputs (C_7)	Students feel more under pressure (M_6) and tend to focus on technical things to meet industry expectation (M_7).	Students may have a bad impression on the placement (O_{5-}) and lead to the issue of program reputation (O_{6-}).

The mentor context

The strategies which engineers work with the ChEPS students can be classified into 3 types: facilitation (C_{31}), action (C_{32}), and instruction (C_{33}). How the strategies affect student outcomes is presented in Table 4.

Table 4: The CMO configuration of how the industry mentor affects student outcomes

Context	Mechanism	Outcome
Mentors facilitate students as academics do (C_{31}).	Students are provoked to tackle problems (M_8) as the program expected.	O_1-O_6 can be expected
Mentors use the strategy of "leading by examples" (C_{32}).	Students find the reasons of what mentor do and develop their own strategy (M_9).	
Mentors tend to instruct students (C_{33}).	Students imitate what mentors do regardless any reason (M_{10}).	Some O_1-O_4 may not be developed and O_{5-}-O_{6-} may be occurred.
	Students follow mentors' instruction (M_{11}).	

A student said *"my mentor was so nice, when I needed his advice. After regular working hours; he always spent time discussing (C_{31}) about our problems. He never directly told me an answer but most of the time I learnt from his questions (M_8)"*. While another student said *"my mentor never explained (C_{32}) what and why he did. I had to observe it and try to find answers by myself (M_9)"*. The interviewer asked, *"How could you make sure your answer was right or wrong?"* He said *"some were not right or wrong answers. However, if I really needed an answer, I would ask him then"*.

Another type of mentor strategy was mentioned by an academic supervisor. He observed that some students could not fully understand what they were doing since they just follow the mentor instruction (M_{11}) or some students just imitated what mentor did (M_{10}). *"Personally, I'm concerned whether these students could develop their learning as we expected"*, added the advisor.

Discussion

RE was employed for this investigation since this framework considers the importance of contexts. The data analysis shows that even though students could gain benefits from ChEPS as the program stakeholders expected (Table 2), there still are some possible mechanisms that cause unwanted outcomes at placement (Table 3,4). The CMO configurations lead to a better understanding between the university and the placement, and the awareness of mentor teaching strategies.

Better understanding between the university and the placement

To operate WIL programs successfully, common understandings among program stakeholders are necessary (Cooper, et al., 2010). The ChEPS operation handbook which the program stakeholders are supposed to read includes roles and responsibilities of stakeholders, and expected student learning outcomes. However, the expectations of the placement are excluded in the handbook. Thus, it should be better if the clear objectives of the placement participation are firstly agreed and, significantly, the participation objectives should be specified in the document.

The awareness of mentor teaching strategies

How a mentor works with a student is uncontrollable. However, the mentor approach to teaching (C_{31}, C_{32}, C_{33}) should be discussed in formal and informal meetings. In addition, expected mentor strategies should be specified in the handbook. An academic advisor should maintain communication with students in case they need help. For instance, an advisor may ask a student about their reasons for the approach to problem solving if he/she is working with an action mentor (C_{32}). Moreover, a formal meeting between an academic and a mentor is required if the mentor just focuses on project outcomes (C_{33}) instead of supporting the student learning.

Conclusion

RE is employed by this research due to the difficulties of experimental approach, and the contextual impacts in educational program. In this study, RE uncovers the possibilities of how placement policy and mentor attitude influence student outcomes. In the end, a deeper understanding of the contextual influences on the student outcomes can lead to a better understanding between the university and the placement, and the awareness of mentor teaching strategies.

References

Billett, S. (2002). Workplace pedagogic practices: Participation and learning. *Australian Vocational Education Review, 9*(1), 28-37.

Blackwood, B., O'Halloran, P., & Porter, S. (2010). On the problems of mixing RCTs with qualitative research: the case of the MRC framework for the evaluation of complex healthcare interventions. *Journal of Research in Nursing, 15*(6), 511-521.

Blamey, A., & MacKenzie, M. (2007). Theories of change and realistic evaluation: Peas in a pod or apples and oranges? *Evaluation, 13*(4), 439-455.

Campbell, D., & Stanley, J. (1963). *Experimental and quai=si-experimental evaluations in social research*. Chicago: Rand McNally.

Cooper, L., Orrell, J., & Bowden, M. (2010). *Work integrated learning : A guide to effective practice*. New York: Routledge.

Heywood, J. (2005). Assessment and evaluation. In J. Heywood (Ed.), *Engineering education : research and development in curriculum and instruction* Piscataway, N.J.: IEEE Press

Johnston, B. S., Meadowcroft, T. A., Franz, A. J., & Hatton, T. A. (1994). The M.I.T. practice school: Intensive practical education in chemical engineering. *Chemical Engineering Education, 28*(1).

Kirby, J. R., Knapper, C. K., Evans, C. J., Carty, A. E., & Gadula, C. (2003). Approaches to learning at work and workplace climate. *International Journal of Training and Development, 7*(1), 31-52.

Ku, H., & Thonglek, S. (2011). Running a successful practice school: Challenges and lessons learned. In P. Keleher, A. Patil & R. E. Harreveld (Eds.), *Work-integrated learning in engineering, built environment and technology : Diversity of practice in practice* Hershey, PA: Information Science Reference.

Patrick, C., Peach, D., & Pocknee, C. (2009). *The WIL [Work Integrated Learning] Report: A National Scoping Study [Australian Learning and Teaching Council (ALTC) Final report]* (No. ISBN 978-1-74107-254-9). Brisbane: Queensland University of Technology.

Pawson, R., & Tilley, N. (1997). *Realistic evaluation* Thousand Oaks, California: Sage.

Precision Consultancy. (2007). *Graduate Employability Skills prepared for the Business, Industry and Higher Education Collaboration Council*. Retrieved from www.precisionconsultancy.com.au on 17 Jun 2010.

Saunders, M. (1995). The integrative principle: Higher education and work-based learning in the UK. *European Journal of Education, 30*(2), 203-216.

Shadish, W. R., & Luellen, J. K. (2004). Donald Campbell: The accidental evaluator. In M. C. Alkin (Ed.), *Evaluation roots : tracing theorists' views and influences* Thousand Oaks, Calif: Sage Publications.

Tilley, N. (2000). *Realistic evaluation: An overview*. Paper presented at the the Founding Conference of the Danish Evaluation Society. Retrieved from http://www.evidence-basedmanagement.com/research_practice/articles/nick_tilley.pdf on 27 Mar 2011.

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