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Industrial Based Learning for Improving Problem Solving Skill for Technical and Engineering Workforce Labour

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The objectives of this research were to develop the industrial based learning for improving problem solving skill for technical and engineering workforce labour. Starting from creation of industrial based learning (IBL) that integrated CIPP model which consist of context evaluation, input evaluation, process evaluation and product evaluation, identification of problem solving skill, creation of research tools, identification of population and sample, implementation of industrial based learning for improving problem solving skill for technical and engineering workforce labour that was designed with Phradabos's students who study in the project course I and II and TM-FTE-KMUTNB's students who study in project course I and II, and then collect data, analysis and conclusion. The result found that the efficiency of problem based learning in project course was 84.24/80.20 and 91.38/85.21 that were above 80/80 established criteria, the advanced abilities after learning of students who learned from industrial based learning in project course increased more than before learning, a knowledge and abilities of students were improved, the problem solving skill (PSS) of students passing the project course I and II which is higher than the previous time. Phradabos's students had average problem solving skill at Level 2 and TM-FTE-KMUTNB's students had average problem solving skill at Level 3 which can meet industrial requirements.

Keywords: Industrial based learning, problem solving skill, technical workforce labour, engineering workforce labour.

1. Introduction

Teaching and learning management for the technical and vocational diploma program in Thailand which are industrial subject, commercial subject, agriculture subject, home economics subject and fine arts subject. The program is consisted of basic courses, specific courses, elective courses, experience training and project courses [1]. The bachelor of science in technical education in mechanical engineering program which is consisted of general

education course, specific course, elective course, experience training and project course. The project course is selected and taken by students which was done in the form of group work, for completion of the program. However, the problem solving skill of students are not complete according to the competency standard [2]-[3] and these projects may not meet the needs for solving working problems in the actual industrial context since many teachers often taught in traditional way. Therefore, this will affect vocational education quality and student's knowledge and skills for working in the future work. Thus, both educational and industrial sectors have cooperation for improving the project course to solve problems in the workplace. In the present many technical college and university in Thailand applied cooperative learning, industrial-oriented education [4], industrial based learning, hand-on model, learning factories [5] and active learning for learning and teaching. Industrial based learning: IBL was a part of active learning. IBL has since been extended in applications for other programs of learning and teaching which has been pivotal in preparing the undergraduate students in Australia more than 25 years ago and in New Zealand, UK, USA and Indonesia thus IBL is the benchmark in work-integrated learning for industry and offering placement opportunities for undergraduate students through the IBL. The process of IBL allows for students to develop their knowledge and skills used for their future work. It increases critical appraisal, literature retrieval, encourages ongoing learning within a team environment and reflects the outstanding quality of students [6]. Industrial based learning has been applied in teaching and learning and suitable for project course in technical and vocational diploma program and the bachelor of science in technical education in mechanical engineering program that was implemented for Phrada Bos's students and students of Department of Teacher Training in Mechanical Engineering (TM-FTE-KMUTNB). Phradabos school is operated by Phradabos foundation that is Royal project under the Royal initiative of King Rama 9, was established in 1966. The first aim of Phradabos school is help educational disadvantaged person, poor, unemployed and not enough basic knowledge to study at vocational institute but those people are interest in learning and have earnest perseverance, and the second aim is to give the opportunity in the professional and moral training for them are able to persuade a career, develop their own position, help family social and country. At present many students are border tribes, orphans, youth who were treated of drug cessation, released from prison. Phradabos school education is informal education that train in auto mechanic, electronic technician, electrician, sufficiency agriculture technician, maintenance technician, construction and carpenter, welder and nursing home [7]. Phradabos foundation estabblshed Lukphradabos school in 1998 for transfer agriculture technology and renewable energy knowledge and established Southern Border Provinces Phradabos School in 2010 which was second school for help of youth of three southern border provinces who were affected by terrorism, for train in auto mechanic, motorcycle mechanic and agriculture machinery technician. In Present Department of Teacher Training in Mechanical Engineering (TM), Faculty of Technical Education (FTE), King Mongkut's University of Technology North Bangkok (KMUTNB) has implemented industrial internship program at bachelor's degree and Phradabos school has implemented the dual vocational training project at diploma level which cooperates with Nakornluang Polytechnic College (NPC), Donmuang Technical College (DMTC), Dusit Technical College (DTC), Samutprakan Polytechnic College and Kanchanaphisek Nongchok Industrial and Community Education College (KNICE) but student's learning achievement is low and not meet the requirements of industry. Based on the importance and previous studies about teaching and learning in project

subject, the researcher has decided to develop the industrial based learning in project courses for improving problem solving skill and actual work in the workplace. One research question has been addressed: Can IBL use in the project? Industrial based learning in a project course for actual work in the workplace consist of CIPP-MIAP-PBL-3 steps of IBL model, lesson plan, chalk board layout, question list, teaching aids, exercises and keys, examination, assessment form of Vocational Education Commission and evaluation form. The main objectives of this research were as follows:

1. Develop the industrial based learning in vocational diploma program and the bachelor of science in technical education in mechanical engineering program improving problem solving skill and actual work in the workplace.

2. Assess the problem solving skill of students.

3. Evaluate the efficiency of learning of the industrial based learning in vocational diploma program and bachelor's degree for actual work in the workplace.

4. Analyze advanced abilities of students.

5. Evaluate the industrial requirements for project workpieces of students.

6. Evaluate student's achievement.

2. Literature Review

A. Industrial based learning

The industrial based learning (IBL) was a part of active learning. It was applied with teaching and learning in many programs which was mostly about computer, programing and information technology, for undergraduate students more than 25 years ago in Australia [8]-[10] and other places such as New Zealand [11], UK [12], USA [13], Indonesia [14], Kenya [15], etc. IBL has been pivotal in preparing knowledge, skill and attitude of workforce to meet the current and project demands of the global, 21th century and preparing students for meaningful engagement in postsecondary education, in workplace training that relevant to their studies and in career pathway. The students will graduate with knowledge, skill and experience needed to success in learning [16], work and life and many graduating students receive multiple job offers in their final year thus IBL is the benchmark in work-integrated learning for industry. The process of IBL allows for students to develop their knowledge and skills used for their future work. It increases critical appraisal, literature retrieval, encourages ongoing learning within a team environment and reflects the outstanding quality of students and effected the development of teachers also [17]. There was main three steps that comprise of admission, industrial placement and assessment and credit.

B. CIPP

The CIPP is evaluation model that developed by Daniel Stufflebeam and their colleagues in 1960. CIPP process comprise of C: context evaluation, I: input evaluation, P: process evaluation and P: product evaluation.

C. Problem solving skill

The problem solving skill is a complex skill that is one of key skills that are used in UK, Scottland and countries in United Kingdom, The national qualification framework (NVQs) was divided in 7 levels in UK which the competency in NVQs comprise of basic skill, common skill and key skill [18] but basic skill of AQF in Australia was called key competencies that comprise of collecting, analysing and organsing ideals, communication ideals and information, planning and organizing activities, working with other and in teams, using mathematical ideals and techniques, solving problem and using technology [19]. In Thailand, it was called national qualification framework (NQF) that was divided in 7 levels same UK and the competency in NQF comprise of core skill and occupational skill which both skills were consist of knowledge, psychomotor skill or ability and attitude. The core skill consists of communication, calculation, using information technology, analytic thinking and problem solving and working in teams [20]. The key skill is a range of essential generic skills that underpin success in education, employment, lifelong learning and personal development. People are practical, applied skills relevant both. People in UK will often be developed through other subjects or main programmes but many people also be studied in their own right [21]. Problem solving skill involves with critical thinking, analytic thinking, decision making, creative thinking and information processing [22]-[24]. The three basic step of problem solving that for common job and life comprise of identify the problem, generate a list of possible solutions and implement the solution [25] and the five primary steps of careers in problem solving consist of analyze the causes to unwanted solution, generate the set of alternative interventions to achieve goals, evaluate the best solutions, implement a plan and assess effectiveness [26].

D. Problem based learning

Problem based learning (PBL) has been widely applied in teaching and learning. PBL can be defined as a child-centered pedagogy in which students learn about a subject matter and skills practice through the experience of analytic thinking, systematically thinking, problem solving, critical thinking and creative thinking an open-ended problem found in trigger materials that were prepared by instructor. The problem based learning (PBL) process does not concentrate only on problem solving which one of core competencies with a defined solution, but it allows for the development of other desirable skills, attitude and attributes. This includes knowledge acquisition, enhanced group collaboration, numerical thinking, information and communication technology (ICT) and communication. The problem based learning process was developed for medical and nursing education and has since been extended in applications for other programs of learning, teaching and training [27]-[28]. The procedure of problem based learning allows for students to develop knowledge, skills and attitude used in their future practice which should meet industrial requirements. It improves critical appraisal, literature retrieval and encourages ongoing learning within a team environment. The process of problem based learning consist of clarifying unfamiliar terms, problem definition, brainstorm, analyzing the problem, formulating learning issues, self-study and reporting [29]. The problem based learning consist of driving questions or challenges, inquiry and innovation, 21th century skills, student voice and choices, feedback and revision and publicy presented product. Problem based learning (PBL) is similar to Project based learning (PjBL) which is a student-driven, "teacher-facilitated approach to learning. The teaching method in which students gain knowledge, skills and attitude by working for an extended period of time to investigate and

respond to an authentic, engaging, and complex question, problem, or challenge. Both learning are applied to vocational and technical and engineering education for encouraging student's skills for 21th century: skills for the future [30]-[33].

E. MIAP teaching method

MIAP teaching method was used in learning and teaching for a long time in Department of Teacher Training in Mechanical Engineering, in Electrical Engineering and in Civil Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok that well known in Thai-German. MIAP was known to be widespread in vocational and technical college of Thailand. The teaching technique is questioning which teacher must prepare question and answer list to help learning of students thus MIAP teaching method can be defined as a child-centered pedagogy. This teaching method consists of 4 steps as follows: 1) M: Motivation 2) I: Information 3) A: Application 4) P: Progression thus MIAP was integrated with 7 steps of PBL for this research [34]-[35].

3. Materials and Methodology

This research was an experimental research as shown in Figure 1. The research model followed IBL integrated with CIPP with MIAP and questioning teaching method and 7 steps of problem based learning: PBL.

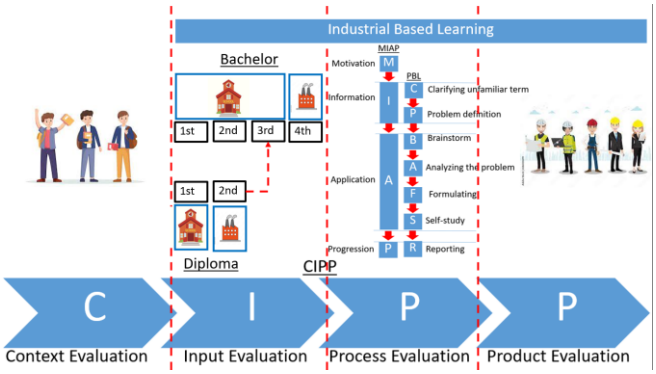

Figure 1. IBL-CIPP-MIAP-7 Steps of PBL model.

First, the IBL program was divided two parts, first part is studying of IBL program in school and second part is internship of IBL program in industry placements along with studying project course I and II. The student's behavior and background, industrial based learning, problem solving skill, project course I and II description, problem based learning and industrial requirements for improving problem solving skill for technical and engineering workforce labour were analyzed for learning and teaching and then design and development industrial based learning (IBL) which integrated with MIAP teaching method: 1) Motivation 2) Information 3) Application 4) Progression, questioning teaching method and 7 steps of PBL that comprise of 1) C: clarifying unfamiliar term 2) P: problem definition 3) B: brainstorm 4) A: analyzing the problem 5) F: formulating learning issues 6) S: self-study 7) R: reporting. Almost Phrada Bos students and TM-TE-KMUTNB's students as shown in Figure 2. They were poor but those people are interest in learning and have earnest perseverance.

Figure 2. IBL internship of TM-FTE-KMUTNB's students.

F. Industrial based learning

The population was workforce labor that studying in 2nd year internship of IBL program and studied at a diploma certificate level, in 4th year internship of IBL program and studied at a bachelor's degree in IBL program. The sampling group were Phrada Bos's students who studied at diploma certificate level and TM-FTE-KMUTNB's students who studied at bachelor's degree in project course I and II of the industrial based learning program. Phrada Bos's students were 50 registered persons and TM-FTE-KMUTNB's students were 16 registered persons.

G. CIPP

IBL was evaluated by CIPP model. First, evaluate the context such as industrial requirements, law and regulation, technician and engineering workforce labour, etc. Second, evaluate the students, admission, learning and teaching, problem solving skill, resource, etc. Third, evaluate the learning outcome between learning, satisfaction of students, problem between learning and teaching, etc. Fourth, evaluate competency, efficiency of learning, advanced abilities, project workpieces, student's achievement, satisfaction.

H. Problem solving skill

The problem solving skill that was created from the both core skill of Thailand NQF and basic skill of NVQs. Topics in the course description of project course I and II were analyzed by coral analysis technique in order to sub-topics, main elements and course expected learning outcome: CLO that consist of knowledge, skills and attitude.

I. MIAP teaching method

Research tools comprise of lesson plans, chalk board layout, question list, teaching aids, exercises and keys, examination, competency assessment form, assessment form of the Vocational Education Commission that was assessed student's achievement, evaluation form which was used evaluated industrial requirements for project workpieces of students, document templates, laboratory, LINE group, Google classroom and computer room that shown in Figure 3.

Figure 3. Computer room.

4. Results

The assessment of competency of industrial based learning for improving problem solving skill for technical and engineering workforce labour who studied at diploma certificate level and bachelor's degree in industrial based learning program. Phrada Bos's students were 50 persons and TM-FTE-KMUTNB's students were 16 registered persons. The problem solving skill competency units comprise of PS 2.1, PS 2.2 and PS 2.3 for technician, PS 3.1, PS 3.2 and PS 3.3 for engineer that are assessed and presented in table 1. The results presented of Phrada Bos's students that the pre-test was fair level with average score 20.86 (S.D. = 6.71), the post-test was good level with average score 61.51 (S.D. = 7.94). The results presented of TM-FTE-KUMTNB's students that the pre-test was fair level with average score 40.56 (S.D. = 2.24), the post-test was good level with average score 77.81 (S.D. = 2.83). The results revealed that industrial based learning for improving problem solving skill was good and student's problem solving skill were good level and increasing.

Table 1. Assessment of problem solving skill of students.

Competency	Pre-test		Post-test	
	Averg.	Stdev.	Averg.	Stdev.
Phrada Bos's students				
PS 2.1 [1]	21.00	6.91	62.00	7.90
PS 2.2 [2]	20.86	6.72	61.55	7.89
PS 2.3 [3]	20.72	6.52	60.97	8.03
Average	20.86	6.71	61.51	7.94
TM-FTE-KMUTNB's students				
PS 3.1 [4]	40.69	2.30	77.88	2.80
PS 3.2 [5]	40.44	2.13	77.69	2.89
PS 3.3 [6]	40.56	2.28	74.50	2.80
Average	40.56	2.24	77.81	2.83

[1] Identify a problem, with help from an appropriate person, and identify different way of tackling it.

[2] Plan and try out at least one way of solving the problem.

[3] Check if the problem has been solved and identify way to improve problem solving skills.

[4] Explore a problem and identify different ways of tackling it.

[5] Plan and implement at least one way of solving the Problem.

[6] Check if the problem has been solved and review your approach to problem solving.

The efficiency result of industrial based learning for improving problem solving skill for technical and engineering workforce labour compared between process efficiency (E1) and output efficiency (E2) is presented in table 2. The result of the efficiency of industrial based learning for improving problem solving skill presented that process efficiency and output efficiency E1/E2 was 84.24/80.20 for Phrada Bos's students, 91.38/85.21 for TM-FTE-KMUTNB's students that were above 80/80 established criteria. The result revealed that industrial based learning for improving problem solving skill can be used effectively in 2nd year internship of IBL program and project course for diploma certificate Phrada Bos's students and bachelor's degree TM-FT-KMUTNB's students in the industrial based learning program.

Table 2. Efficiency of industrial based learning for improving problem solving skill.

Evaluation	Total score	Average	Efficiency
Phrada Bos's students			
E1	50	42.12	84.24
E2	30	24.06	80.20
TM-FTE-KMUTNB's students			
E1	50	45.69	91.38
E2	30	25.56	85.21

Table 3 and Figure 4 showed that the scores measured and evaluated learning outcome of students between before studying and after studying by assessing the statistic t-test for dependence with significance at the 0.01 level. The advanced abilities after studying of students who studied from industrial based learning for improving problem solving skill increased more than before studying. As result t-test which was significantly different at 0.01 levels. The result founded that knowledge, skills and attitude of students were improved.

Table 3. Analysis of advanced abilities.

N	ΣX	ΣD	ΣD^2	t
Phrada Bos's students				
Pre-test 50	8.98	754	11636	45.79
Post-test 50	24.06			
TM-FTE-KMUTNB's students				
Pre-test 16	7.68	286	5154	42.85
Post-test 16	25.56			

The Phrada Bos's student who studied at diploma certificate level were 50 persons and TM-FTE-KMUTNB's students who studied at bachelor's degree were 16 persons in industrial based learning project. Table 4 presented that project workpieces were good level with average score 4.40 (Phrada Bos) and 4.50 (TM-FTE-KMUTNB). The results revealed that industrial based learning for improving problem solving skill was good and student's learning achievement were good level. Moreover, most of the project workpieces can meet industrial

requirements.

Table 4. Evaluation of project workpieces.

	Phrada Bos	TM-KMUTNB
Appropriated design	4.42	4.58
Drawing & specification	4.33	4.67
Production	4.58	4.75
Valuation	4.75	4.75
Presentation	4.17	4.17
Supported document	4.08	4.08
Ethic & code of conduct	4.50	4.50
Average	4.40	4.50

The result of table 5 presented that the Phrada Bos's students learning achievement were 50 persons and TM-FTE-KMUTNB's students learning achievement were 16 persons which is high.

Table 5. Evaluation of student's achievement.

	Admission	Achievement
Phrada Bos's students	50	50
TM-FTE-KMUTNB's students	16	16

The satisfaction of industrial based learning (IBL) for improving problem solving skill for technical and engineering workforce labour consist of the admission, computer room, laboratory, LINE group, Google classroom, essential theory, progression, document template, MIAP teaching method, collage service and industry placement are shown in Figure 5 and the student's projects which improving the problem solving skill of students and solving the working problem in actual industrial context that are shown in Figure 6. The result of the evaluation showed that industrial based learning for improving problem solving skill was good with average score 4.41 (S.D. = 0.61).

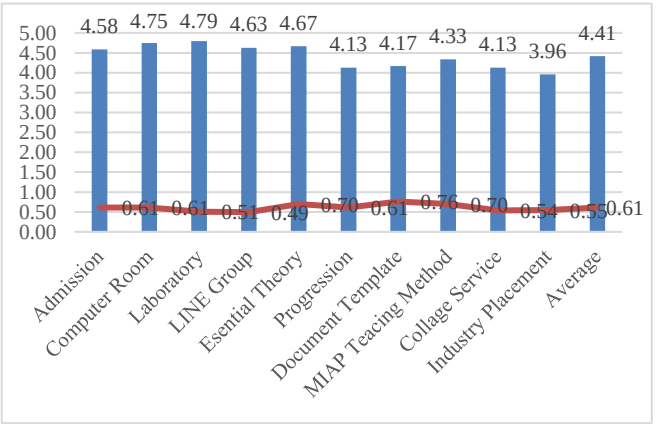

Figure 5. Evaluation of satisfaction of industrial based learning for improving problem solving skill for technical and engineering workforce labour.

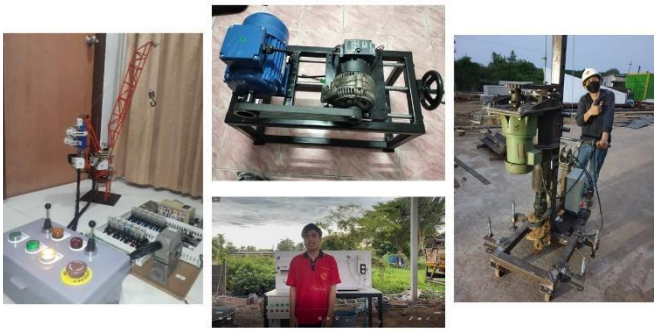

Figure 6. Student's projects that solving working problem in actual industrial context

5. Conclusion

The implemented and finished the industrial based learning for improving problem solving skill for technical and engineering workforce labour, the problem solving skill assessment presented that the pre-test was fair level with average score 20.86 (S.D. = 6.71), the post-test was good level with average score 61.51 (S.D. = 7.94) for Phrada Bos's students, the pre-test was fair level with average score 40.56 (S.D. = 2.24), the post-test was good level with average score 77.81 (S.D. = 2.83) for TM-FTE-KMUTNB's students, the efficiency of industrial based learning for improving problem solving skill was 84.24/80.20 for Phrada Bos's students, 91.38/85.21 for TM-FTE-KMUTNB's students that were above 80/80 established criteria. The advanced abilities after learning of students who learned from industrial based learning for improving problem solving skill increased more than before learning and abilities that met their requirements were developed by IBL, the project workpieces were good level with average score 4.40 (Phrada Bos) and 4.50 (TM-FTE-KMUTNB), Almost project workpieces can meet industrial requirement, the Phrada Bos's student learning achievement is 50 persons and TM-FTE-KMUTNB's students were 16 persons that is high and the evaluation of satisfaction of problem based learning in project course was good with the average score 4.41 (S.D. = 0.61). In the conclusion from the above results, the implementation of industrial based learning for improving problem solving skill for technical and engineering workforce labour can be completely used to learn for Phrada Bos's students and TM-FTE-KMUTNB's students in the industrial based learning program. For the further, next time we will implement this method to improve other core competency.

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