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Analysis and Determination of Program Learning Outcome (PLO) Based on Work Process for Bio-fuel Industry: A Case Study of Biological Engineering Students

Abstract

Program learning outcomes (PLO) are the skills, competencies, and concepts students should be able to articulate, put into action, or utilize (theoretically or pragmatically) after the completion of a degree or certificate. This work was conducted to develop the program-learning outcome (PLO) of biological engineering students for the bio-fuel industry. The study focused on a palm oil company and was carried out in cooperation with Rajamangala University of Technology Lanna (RMUTL). The PLO design was based on the work process to meet company requirements. The study began by understanding the palm oil process, analyzing the work program by determining the required abilities and skills in each section or department. Next, the investigated data was validated with company team members, including a technician, engineer, supervisor manager and the CEO. Six program learning outcomes (PLO) were obtained from this study. Finally, a study program and its composite subjects will be designed and applied to drive the student towards achieving his/her program learning outcomes.

Keywords: *Program Learning Outcome (PLO), Work Integrated Learning (WiL), Biological Engineering*

1 Introduction

Rajamangala University of Technology Lanna (RMUTL) is a tertiary institution aimed at producing technology professionals, especially those who graduated from vocational schools. Therefore, the university focuses on the education of technical personnel at all levels, from lower to university levels. Furthermore, the university also believes that graduates must be equipped not only with the theory but also the practicability required by an entrepreneurial sector. The reasons for this vision are that the establishment prefers highly qualified personnel who can cope with modern technology, whereas the institution maintains academic knowledge in preparing both hard-skills and soft-skills for students to develop expertise in confronting authentic situations. Hence, educational institutes must develop students in alignment with the regulatory system model suitable for cooperative education management. This necessitates the development of a curriculum, teaching methods, and personnel focused on integrating work and learning. This project has, therefore, endeavoured to establish a bridge between the government agency and the private sector by putting the policy into action and developing a model and system for vocational education which will produce further

technical personnel. To clarify: basic education institutions are an upstream which produces feeders for vocational and higher education institutions – a midstream, where cooperative education between work and learning is initiated. The private sector, a downstream, is to create a pilot pattern for further expansion following the mission of Rajamangala University of Technology Lanna. In 2018, Rajamangala University of Technology Lanna operated a work-integrated learning program in collaboration with a private company and run by the ministry of education, Thailand. It was called the “developing the new species of graduate” project . RMUTL has 6 bachelor degree courses and 4 vocational degree courses with 10 companies in several different industry sectors which contributed to this project, such as the electronic industry (Fujikura electronic Ltd.), the vehicle industry (BDI group Ltd.), the mechatronic industry (Star holding group Ltd.), the rubber industry (Michelin Ltd.), the agro-industry (Betagro Group Ltd.) etc. The objective of the “developing new species of the graduate” is to enhance students’ performance and ability through multidisciplinary integration to meet a company’s needs - especially those companies in the ten private sectors of the New S-Curve, an important mechanism for driving the economy (New Growth Engines) of the country. Ten private sectors of the New S-Curve consist of 2 groups, five of are in the first S-Curve and five in the new S-Curve, as shown in Figure 1. The ten private sectors are: next-generation automotive, smart electronic, wellness tourism, agricultural and biotechnology, food for future, robotics, aviation and logistics, biofuels and the biochemical, digital and medical industries.

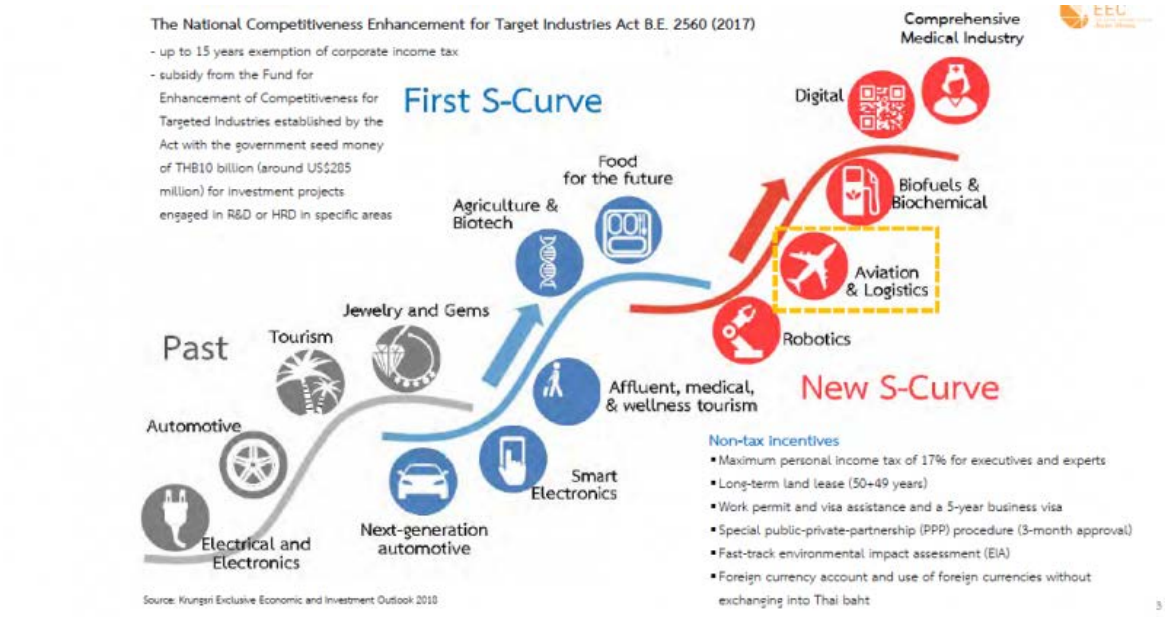

Figure 1: Ten private sectors of the new S-Curve driving the economy of Thailand (Krungsri Economic and Investment Outlook 2010)

One of the bachelor degrees linked to the “developing the new species of the graduate” project is the Bachelor of Engineering in Agricultural and Biological Engineering Program with Bio Story Group Co., Ltd. (Formerly: Anatta Green Group Co., Ltd). To achieve the goal of the project, the program learning outcome (PLO) needs to be developed. This paper

aims to describe the process and model of developing the PLO for the biological engineering student in a bio-industry company.

2 Work-integrated Learning (WiL) in Thailand

Before delving into the objectives of implementing Work-integrated Learning (WiL) in Thailand, it is important to offer some definitions to help understand the approach more thoroughly. Many researchers and experts present their own definitions of WiL. One of the most interesting explanations relates to experiential learning: students can apply knowledge, work skills, and specific skills with real-life relevancy which they learned in the classroom to real-life situations before graduation (Yamnoon 2009). It also means the integration of academic and work experience via various forms such as education, research, internships, social work, working in the workplace, or professional experience (Karnpakdee 2017). In short, WiL helps to unite the knowledge students have learned in the classroom with the professional skills required by private sectors through various methods.

To promote the objective of Work-integrated Learning in Thailand, Chinintorn & Plaimart (2011) sought to connect education to the industrial business sector with a view to preparing personnel who are highly capable of competing in the international workforce. However, to achieve this goal, academic institutions and private sectors must cooperate, so that both of them can reap equal rewards.

WiL is a useful pedagogy for academic institutions; however, the quality of higher education in Thailand still struggles in terms of quality. Its higher education institutions struggle to produce graduates of the standard required by the workforce/labor market. Moreover, students lack the necessary knowledge and social skills and are consequently poorly equipped for the demands of work. This skills and knowledge crisis was confirmed by the World Economic Forum (2010) which noted that Thailand had dropped from 34th place in 2009 to 36th in 2010 in a total of 131 countries in terms of competitive ability. The most important characteristics are technological ability, education quality, and institutional strength. Solutions outlined in phase 2 (2008-2022) of the framework of long-term tertiary education plans, quality deficiencies can be alleviated by changing the pattern of tertiary education management to a unified effort among university groups and professional and academic associations (Office of education in Thailand 2010). A system needs to be designed which connects higher education institutions and private sectors, creating a mission which aspires to a demand-led curriculum with technical services and research playing key roles. University science and technology departments will prove to be focal points. The attempt to find a model supporting the Work-integrated Learning model is a highly appropriate course of action in an educational context and in Thai society (Chininthrone & Plaimart 2011).

According to the aforementioned statements, the scope of the curriculum and the pedagogical process of Work-integrated Learning in Thailand should be as follows:

1. Multidisciplinary integration in a curriculum for graduates or workers to serve the ten private sectors of the new S-Curve, an important mechanism for driving the economy (New Growth Engines) of the country
2. Integrating experiential learning which supports cooperation between educational sectors and private sectors to respond to the needs of the private sectors
3. Systematically Integrating life skills of digital society and professional skills with general education courses
4. Setting up modular-based learning outcomes and learning results between educational institutions and private sectors to meet the needs of private sectors, especially at the beginning and in the middle of the new S-Curve
5. Creating the curriculum and managing learning to support the needs of personalized learning development or the whole campus

3 Cooperation between the university and company in the research process

Rajamangala University of Technology Lanna (RMUTL) established a pilot development project to integrate the educational management model of learning and working together with National Science Technology and Innovation Policy Office (STI) in the form of a school in the factory. This kind of a learning model actually sets up the classroom and study activity inside the factory or company. At present, teaching and learning at the in-factory school cover all levels of education, from vocational certificates to high school, preparing so-called “WiL feeder” graduates for factories. WiL feeder refers to the production of high-level vocational technicians to feed to factories, vocational teachers and engineers at Bachelor’s Degree level. This includes the production of a Master’s Degree Engineer who can teach at a high vocational level in factories under the Mentors in Factories program. This program, currently supported by Chevron Enjoy Science Project as a TVET HUB LANNA, aims to expand the results of educational management under the WiL principle by establishing the first coordination centre in Thailand. The centre launches implementation to all RMUTLs in six campuses located in each province. Moreover, to succeed in WiLeducational management, the network has been expanded to manage administration and to widen the content of the education model. The centre is also rapidly intensifying the integration of learning and working; encouraging the development of manpower both in the formal and non-formal education systems for the country, raising the level of competitiveness through increased productivity and innovation.

In 2015, the Lanna Vocational Training Center and TVET HUB LANNA cooperated (MOU) with many entrepreneurs. One of them is Bio Story Group Company Limited, which operates in the agro-industry business to produce palm oil and is about to launch a school in the factory (SiF) together with the Rajamangala University of Technology Lanna. The course offered is Bachelor of Engineering, Agricultural and Biological Engineering Program, Rajamangala University of Technology Lanna. The curriculum has ben adjusted to match the actual work or performance of Bio Story Group which will initially be used in the course.

However, the program will develop a new style of teaching and learning in acompetency-based curriculum to match the needs of the company. Creating the curriculum requires cooperation and preparation in every aspect such as human resources, the teaching curriculum itself, research, feeder aspects and so on. The objective is to enable the project to be driven efficiently and to meet the needs of all parties. The basis of the cooperation is depicted in Figure 2, which is the part of the Tripartite TVET System (Moonpa, Palasoon, Gulich & Beeker 2019).

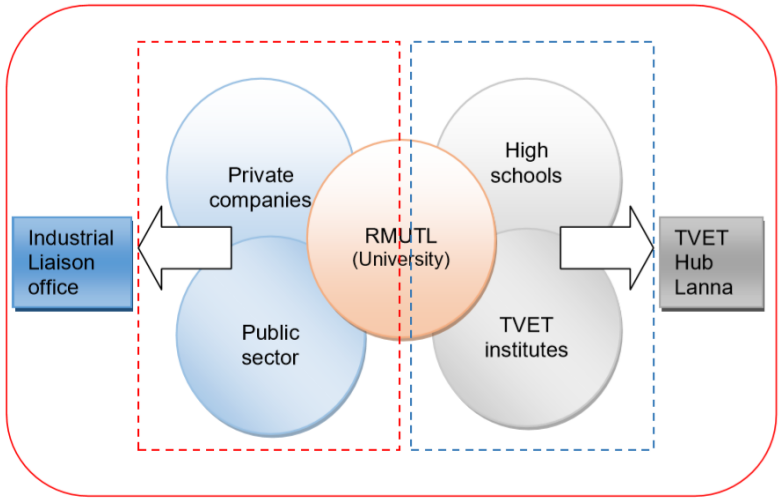

Figure 2: Cooperation between the university and company in the research process (Moonpa, Palasoon, Gulich & Beeker 2019)

4 Program Learning Outcome (PLO)

The program learning outcomes were defined as the statements of the knowledge, skills and abilities individual students should possess and can demonstrate upon completion of a learning experience or sequence of learning experiences (Stanford Center for Assessment, Learning and Equity 2017). Further, learning outcomes are the specifications of what a student will have learned and be able to demonstrate on successful completion of the program course. It can also be seen as the desired outcome of the learning process in terms of skills and knowledge acquisition (Aithal & Suresh Kumar 2016). Therefore, the PLO structure must, on the one hand, come from the design and development of the curriculum and on the other hand from the sphere of learning and instruction management. Moreover, due to the fact that the development of PLO must focus on levelling up students' skills and competency to meet the requirements of the new S-Curve - the new growth engines of the country - (Ministry of Education 2016), design and development of the target PLO must be in accordance with the following guidelines.

- The establishment is the platform for learning, instruction, and practice for at least 50 per cent of the study time.
- Lecturers together with staff assigned by the establishment are mentors for the students.

- Experts working in the establishment are assigned to teach the students.
- Lecturers together with the staff of the establishment help to conduct a research study.
- The establishment provides technology and modern tools as learning resources.
- Lecturers together with staff assigned by the establishment evaluate the outcomes indicated in the outcome-based learning or competencies of students.
- The learning process emphasizes levelling up the competency and participation of students.
- Students have the opportunity to employ technology to increase the efficiency and effectiveness of their learning competency.
- The curriculum must integrate learning, instruction, and practice with working in the establishment so that the students can relate their knowledge to real-life situations. Moreover, the establishment must cooperate with the higher education institutions in designing work processes to support outcomes and competency.

5 Methodology of Case Study

5.1 Designing PLO

Regarding the curriculum for the Bio-story Group's students who participated in the project, the design of PLO comprised of various steps as follows:

The first step was initiated by the team of university lecturers that analyzed the Thailand Qualifications Framework (TQF, owned by Rajamangala University of Technology Lanna) to determine which courses should appear in the curriculum. A focus group protocol drawn from the team of university lecturers, the company's CEOs, engineers, and technicians was established to gain insights into the company's needs. The the focus group identified two significant stages of the work process - production and maintenance. Next, they ascertained which other engineering skills and tasks were relevant to students and included these in the development of the prototype (of the curriculum).

After the primary stage, the second step revolved around the program learning outcome (PLO) design. The team of curriculum-deputed university lecturers, the company's CEOs, engineers, and technicians discussed and analyzed the palm oil process (Figure 3) before coming up with 6 core PLOs with 40 sub-PLOs. The process flow chart (Figure 4) below illustrates the design of PLO.

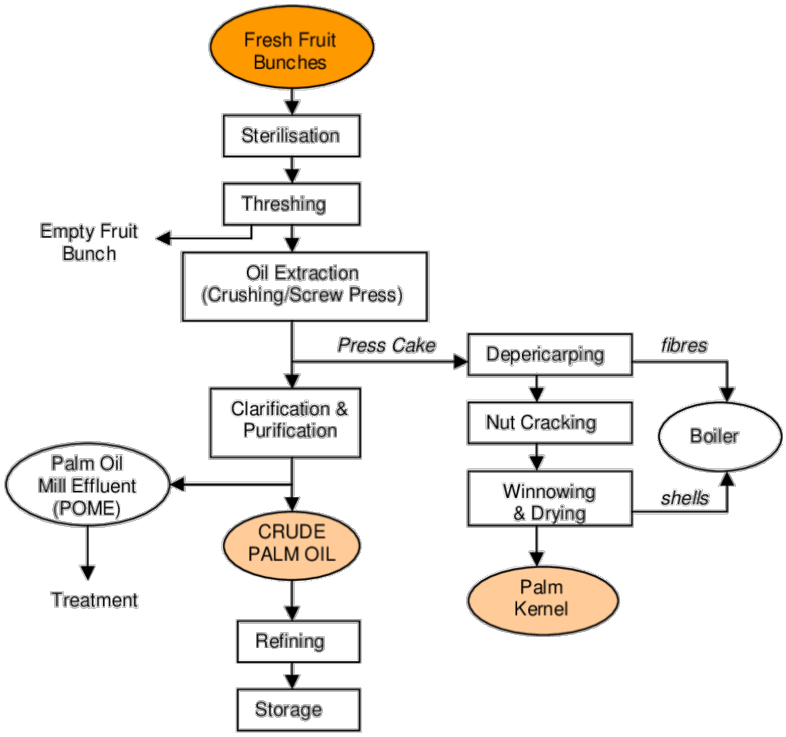

Figure 3: Palm oil process (adapted from FAO 2002)

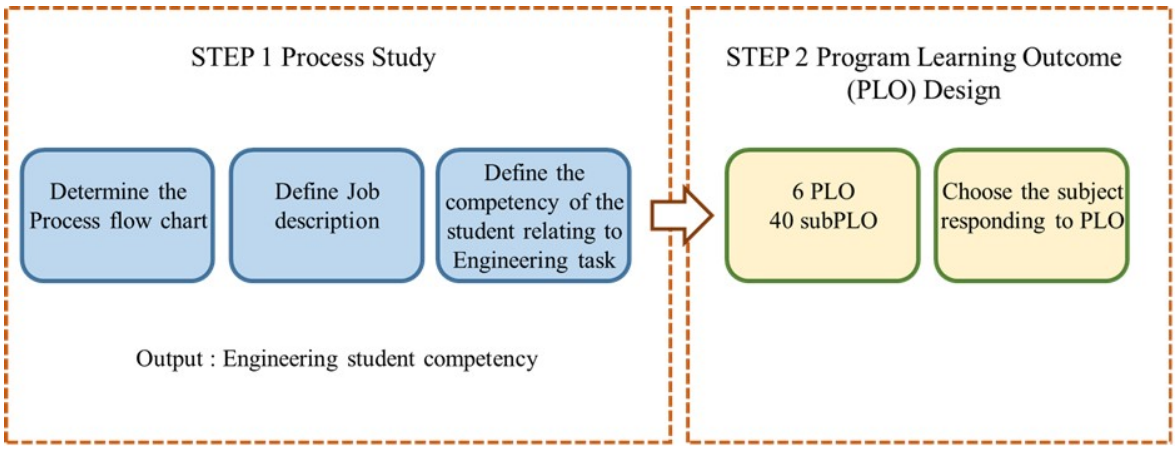

Figure 4: The steps required to designed PLO

The core objective of the program is to develop students into palm oil industry innovators, mentors, and industrial research engineers. In this regard, 13 students who graduated with high vocational diplomas were qualified and selected to involve in the program. Alongside their studies, they have to work as employees in the company for 6 days a week. Students who pass both theoretical and practical examinations will obtain a Bachelor of Engineering Program in Agricultural and Biological Engineering.

5.2 Findings

Having discussed, analyzed, and synthesized the information gathered from both academic mode and company-required mode, a summary of the Program Learning Outcomes (PLO) of the bio-story students covers the following points:

- PLO1: Being able to perform either specific or overall duties assigned by the factory
- PLO2: Being able to maintain and fix factory elements on a level of professional competency
- PLO3: Being able to manage the manufacturing of the company
- PLO4: Being able to manage maintenance
- PLO5: Being able to resolve engineering-related problems
- PLO6: Being able to design a system and industrial products using engineering design

The aforementioned PLOs were then compared with the curriculum and courses specified in a study plan for students. Both the PLOs and the selected courses must maintain three main characteristics: knowledge, skill, and ability. After stipulating and indicating the program learning outcomes, the team concluded that the learning and instruction process must comprise the following 5 modules:

- Module 1: Raw Material / Product
  - Engineering of Material
  - Physical and Biological Properties
  - Bio Energy & Energy Conservation
  - Biological waste management
  - Seminar in Agricultural and Biological Engineering

- Module 2: Process / Unit Operation
  - Calculus 2
  - Applied Mathematics in Engineering)pre-Calculus(
  - Engineering Mechanics
  - Thermo Fluid Engineering
  - Heat and Mass Transfer
  - Unit operation 1 and 2

- Module 3: Design
  - Mechanics of Material
  - Engineering Design
  - Design of Equipment and Production
  - Biological Process
  - Production Management
  - Agricultural and Biological Engineering Project

- Module 4: Process Control
  - Fundamentals of Electrical Engineering
  - Fundamentals of Electronic Engineering
  - Automatic systems
  - Measurement and instruments

- Module 5: Art
  - English for Engineering
  - English for life skills
  - Academic English
  - Art of Using Thai Language
  - Innovation and Technology

In terms of their learning goals, the graduates' objectives should embody the following characteristics after graduation.

1. They can perform duties in the palm oil manufacturing industry with safety and social awareness.
2. They can employ calculating devices and skills to supervise engineering tools used in palm oil manufacturing processes, correctly and appropriately deploying acquired skills in bio and energy engineering, in maintenance work and management.
3. They can effectively manage production and time for both studying and working by using appropriate tools, processes, and methods.
4. They can analyze and solve problems pertaining to the palm oil manufacturing process through use of suitable engineering methods and tools, together with related knowledge and skills in the field of bio and energy engineering.
5. They can use their knowledge of innovative design and development to create new machines and products for the palm oil industry.

6 Conclusion

The program-learning outcome (PLO) of biological engineering students for the bio-fuel industry was investigated and focused in the case study in cooperation with the Rajamangala University of Technology Lanna and the palm oil company. Three groups of people including university lecturers, company's CEOs, and technicians were asked to participate in a focus-group discussion in order to design the PLOs, which met both university and the company requirements. The results revealed 6 core PLOs, emphasizing the ability to work in various parts of the factory, to carry out maintenance the factory on a professional level, to manage the production of the factory, to manage maintenance, to design systems and industrial products. The PLOs developed in this context are compatible with and appropriate to the bio-industry company; however, the process of PLO development must be addressed whenever WiL programs are to be introduced in other companies or businesses, recognizing the different requirements of the companies in question. Moreover, the study of pedagogical

methods should be examined during the primary stage of PLO development so that lecturers and students are able to follow the lesson plans accordingly.

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