A graduate-level chemical engineering practice model in Thailand

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ABSTRACT: The Chemical Engineering Practice School (ChEPS) at King Mongkut's University of Technology Thonburi (KMUTT) in Bangkok is a two-year international curriculum modeled after Massachusetts Institute of Technology's David H. Koch School of Chemical Engineering Practice. The aim of this intensive Master's program is to produce professional chemical engineers with strong fundamentals, practical experience, and a good command of English. The program's uniqueness lies in industrial internships and its strong linkage to the private sector. In this paper, the history and the motivation behind the creation of ChEPS are presented. The uniqueness and key factors contributing to the success of the program are identified. A complete timeline and description of the curriculum are given including a detailed discussion of the practice stations and funding of the program. Finally, the paper provides an impartial assessment of ChEPS based on its output, feedback from industrial sponsors, and the performance of its alumni in the workforce. Eight years after its inception, ChEPS has become one of the top academic programs in Thailand, and is now a flagship curriculum at KMUTT.

INTRODUCTION

The traditional method of learning in engineering disciplines involves classroom lectures, homework assignments, and laboratory work. Although this training is effective to a certain extent, there exists a gap in the skills of students when they step out into the real world. This is particularly true in Southeast Asia including Thailand, where rote learning is the norm [1]. *Spoon-feeding* is prevalent in classrooms even at the college level, and creative thinking is overlooked. As a result, few graduates in Thailand possess the necessary analytical skills to succeed as engineers. To compensate for the deficiencies in the educational system, companies are often forced to invest substantial resources on re-education and on-the-job training for starting engineers.

In addition, the English proficiency of Thai engineering students is on the average subpar. In today's global economy and with a substantial foreign direct investment totaling billions of dollars annually in Thailand [2], the importance of English cannot be overemphasized. Unfortunately, English takes a backseat in most engineering curricula. Students have very limited exposure to English, and there is little incentive for them to improve, as most programs do not have a minimum English requirement for graduation. Finally, companies often complain about the inadequate training of university graduates in communication, be it spoken or written, even in their own native tongue. These facts are hardly surprising, given that nearly all graduate programs are taught in Thai with little emphasis on technical writing and oral presentations.

CHEMICAL ENGINEERING PRACTICE SCHOOL

King Mongkut's University of Technology Thonburi (KMUTT) is an autonomous state institution in Bangkok with a long tradition in engineering. As early as 1996, the university recognized the many shortcomings described above in its engineering programs. Shortly after, KMUTT introduced an initiative to develop a new flagship curriculum aimed at overcoming these deficiencies. The objective was to produce well-rounded engineers who possess strong technical expertise, can communicate effectively, and have good English proficiency. If proven successful, the goal was to expand the initiative to include other curricula.

KMUTT chose Chemical Engineering to be the pilot program. The new curriculum must meet the following criteria:

- *International*. Lectures and presentations must be conducted in English. Reports and homework assignments are written in English as well.
- *Graduate program*, so that it is small enough and can be efficiently managed.
- *Practice-based*, i.e. the curriculum includes compulsory industrial internship.
- *Strong linkage to the private sector*, which offers industrial sites needed for practical training.
- *Adequate funding* to attract top-notch students.

A survey clearly showed that the David H. Koch School of Chemical Engineering Practice at Massachusetts Institute of Technology (MIT) in the US offered all the desired components in its curriculum [3]. The Practice School at MIT was established in 1916 with the goal of supplementing classroom studies with practical training in an industrial environment. The program is truly unique in the US and is found only at MIT. Enrolled students are required to do two academic semesters of coursework, followed by an additional term of industrial internship. This internship replaces the research thesis found in a conventional Master's degree program. An M.S.CEP degree is granted upon graduation.

Graduates of the MIT's Practice School are some of the most sought-after engineers in the country.

Contacts were subsequently made at the highest level between KMUTT and MIT to import the practice-school model into Thailand. The Chemical Engineering Practice School (ChEPS) was thus founded at KMUTT in 1997 [4]. MIT was retained as an advisor, and professors from its practice school traveled to Thailand to help set up the program, assess its readiness, and teach selected courses. The first class of ChEPS consisted of 21 students, all with B.S. degrees in chemical engineering, who were recruited from universities all over Thailand. In subsequent years, 18 - 26 students were admitted annually.

Figure 1 illustrates the four essential components in the practice school, namely the university, the funding agencies, the students, and the industrial linkage. The funding agencies are state, semi-private, and private organizations, which provide research grants and scholarships to academic programs. ChEPS has relied heavily on such agencies for financial support in its operations, particularly during the early years. In a traditional graduate program, the industrial component is normally missing or its role is limited. On the other hand, industrial involvements are vital to the success of a practice school to ensure that students are trained to solve real-life problems early in their studies. These industry-relevant problems are identified by industrial sponsors, and are either brought to the classroom as case studies or solved as site projects during internships.

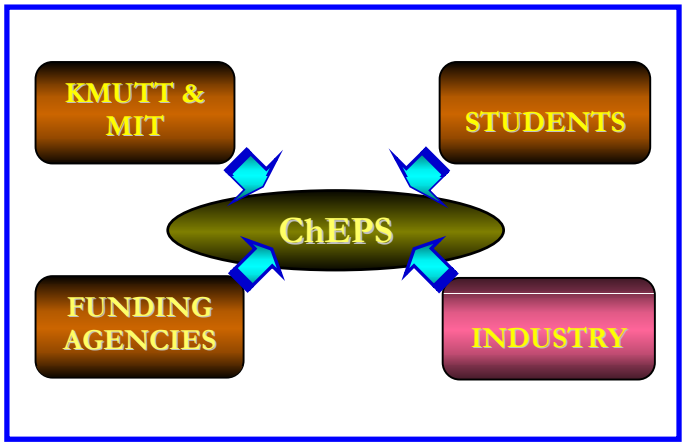

Figure 1. The Four Essential Components of ChEPS

CHEPS CURRICULUM

The ChEPS curriculum consists of one academic year (two semesters and one summer) of coursework, one semester of internship at a practice site, and one semester of research. The coursework is fairly fixed and course electives are kept to a minimum. One objective when starting ChEPS was to introduce Western-styled learning into Thai classrooms. The ChEPS curriculum emphasizes both problem-solving and intensity. The whole program can be viewed as a *learning boot camp*, where problem-based learning is emphasized and students are constantly challenged to solve problems in real plants, sometimes with limited data and many constraints.

Course lecturers consist of both local and overseas instructors, including professors from the US, Canada, the UK, and Australia. First-year courses comprise the following topics:

- Advanced thermodynamics
- Applied mathematics
- Process chemistry, polymer processing, petroleum engineering, and bioprocesses
- Process control and optimization
- Process simulation and modeling
- Reaction kinetics
- Transport phenomena

Despite the similarities, the ChEPS curriculum is not an exact duplicate of the MIT model. Certain components were added to ChEPS to enhance the MIT model and compensate for common weaknesses in Thai students. For example, ChEPS introduced a course in engineering management to enable students to better manage time, people, and projects. Moreover, the program is lengthened to two academic years and one summer to accommodate the intense workload and schedule of the students. Additionally, ChEPS is supplemented with the follow components:

- *Presentations*. Students hone their presentation skills by giving no less than 30 talks by the time they graduate. Presentations are required in every phase of ChEPS, including design problems, research thesis, and site projects.
- *A short research thesis*. Every student must pick a thesis project to be completed in 6 months. The extensive networking of ChEPS inside and outside KMUTT, including overseas institutions, allows a student to choose just about any chemical engineering related topic that is of interest to him. In many cases, research projects are collaborated, which offers an opportunity for students to carry out part of their research outside Thailand, e.g. in Canada, the US, and Singapore. While ChEPS' primary goal is not to produce researchers, many students find the training useful. The students learn to think critically and analytically and must devise a systematic approach to solve a research problem. In fact, many ChEPS graduates have gone on to pursue Ph.D. degrees at another institution, both in Thailand and overseas.
- *English tuition*. ChEPS requires that all students score at least 520 on the paper-based TOEFL or 650 on TOEIC by the end of their second year. This is a daunting task for most students. Hence, extra English courses are provided and students' progress is monitored closely. Students are required take either the TOEFL or TOEIC at least once a year. More recently, a mentoring system has been set up in which faculty members are responsible for a small group of students, helping them improve their writing, presentations, and English in general.

In ChEPS, computers and software packages are heavily used to supplement classroom lectures. Many courses offer hands-on workshops that demonstrate applications of the theories taught. As a result, ChEPS students are well-versed in many simulation programs and programming tools such as ASPEN PLUS™, PRO/II™, MATLAB™, LINDO™, and ControlStation™.

PRACTICE STATIONS

The duration of the practice phase is five months. Students work in teams of two or three on two projects in series, and take turns being the project leader. So each project is 10 weeks long, during which there is a proposal presentation, two progress presentations, and a final presentation. ChEPS faculty on campus also travel to the site and attend these presentations to provide further input. Due to time constraints, most site projects tend to be simulation-oriented, which seek to debottleneck, troubleshoot, and optimize (e.g. minimizing energy consumption) existing plants. A few projects also involve feasibility studies and design of new processes. The practice team can be likened to a consulting team who are dedicated to solving problems for the site company.

It should be stressed that the industrial internship in a practice school is not cooperative study (also known as co-op). The practice model and the co-op study are different in two important aspects. One is the presence of a full-time ChEPS faculty member, called a site director, who is dedicated to a practice station. The site director lives and works with student interns in housing provided by the sponsoring company. While company engineers identify and set the scope of the projects, the site director is responsible for ensuring the academic value of the proposed work, that the project goals are attainable, and that the work is carried out as planned. Furthermore, the site director provides technical advice, prepares students for presentations, and edits students' reports.

The second difference is the commitment of the company at every level to the practice school, starting with providing free housing accommodations, office space, computing facilities, and Internet access. Senior management is first approached, which sets a top-down policy on sponsoring ChEPS. Plant managers, engineers, shift operators, and technicians are also consulted, since they have to interact with the students. A team of engineers is then formed to work closely with students. In a nutshell, the practice school is more systematic and more organized, and is therefore far more efficient than the traditional co-op study.

The following is a list of past and present practice stations in the ChEPS program. Except for ThaiOil which is located in the Sri-racha Province (about 150 kilometers southeast of Bangkok), the remaining companies are all located in the Mathaphut Industrial Estate in the Rayong Province (about 180 kilometers southeast of Bangkok).

- Aromatics (Thailand) Public Co., Ltd. (The) (2002 – 2005)
- BST Elastomers Co., Ltd. (2001 – 2002)
- Thai Oil Public Co., Ltd., (1998 – 2005)
- Thai Polyethylene Co., Ltd. (1998 – 1999, 2001)
- Rayong Olefins Co., Ltd. (2002 – 2003)
- Siam Mitsui PTA Co., Ltd. (2003)

FUNDING CHEPS

To remain competitive, ChEPS offers scholarships and monthly stipends to qualified candidates. The financial support comes from numerous sources, including funding agencies, sponsoring companies, donations, and loan payback from alumni. The funding agencies are:

- Energy Policy and Planning Office (EPPO), formerly National Energy Policy Office (NEPO)
- National Science and Technology Development Agency (NSTDA)
- Petroleum Institute of Thailand (PTIT)
- Suksapattana Foundation

The mission of EPPO under the Ministry of Energy is to foster energy conservation and promote public awareness regarding energy savings. Since ChEPS engineers often help the industry to save money by minimizing energy consumption, EPPO has a direct interest in funding the program. NSTDA is a public organization whose mission is to advance and sustain the economic development of Thailand through research, technology development, and the promotion of collaboration between the public and the private sectors. PTIT is an independent non-profit organization supported by the government, academic and private sectors. PTIT's members comprise of petroleum and petrochemical companies, and the institute's main mission is to assist with the development of the two industries in Thailand in areas of human resource development, information service, and policy and regulatory issues. Finally, Suksapattana Foundation is a non-profit organization dedicated to the development of education and innovation in learning.

Companies who have contributed resources, both in-kind and cash, to ChEPS include:

- BST Elastomers Co., Ltd.
- Thai Lube Base Public Co., Ltd.
- Thai Oil Public Co., Ltd.
- The Aromatics (Thailand) Public Co., Ltd.
- The Siam Cement Group and its subsidiaries

ChEPS in turn offers three types of scholarships to students. Under no circumstances are students required to pay while they study in ChEPS. Those who are not qualified for full scholarships are offered no-interest soft loans, which are to be paid back each month amounting to 10% of their salaries once they start working. Full scholarships are unconditional, while half-scholarship recipients must pay back the other half given out as loans. Together, full and half scholarship recipients account for about two-thirds of the students.

PROGRAM ASSESSMENT

ChEPS is now one of the top academic graduate programs in Thailand. Every year, the program competes for a finite pool of qualified candidates, and is able to attract top students, owing to the program's uniqueness. The success of ChEPS can be judged based on the academic records of the admitted students and the employment profile of its alumni. Table 1 shows the distribution of universities and average GPA's of admitted students from Class-1 to Class-9. The table shows that ChEPS students are well represented by every university in Thailand that has a chemical engineering department. Academically, admitted students are typically ranked in the top 10% of their respective classes with an average GPA of 3.14.

Figure 2 shows the employment profile of ChEPS alumni based on 127 students from 6 classes. About half of the graduates currently work for large chemical, petrochemical, and refinery companies. A sizable number also work for small-to-medium enterprises (SMEs), e.g. those in the sugar and food industries. Finally, about 15% of ChEPS alumni went on to pursue PhD degrees.

Table 1. Academic Profile of Admitted Students in ChEPS

University	Number of Students	Average GPA
Burapha University	5	3.04
Chiangmai University	10	3.29
Chulalongkorn University (Chem. Tech.)	7	3.34
Chulalongkorn University (Chem. Eng.)	13	3.12
Kasetsart University	34	3.04
King Mongkut's University of Technology Ladkrabang	24	3.14
King Mongkut's University of Technology North Bangkok	15	3.09
King Mongkut's University of Technology Thonburi	55	3.14
Khon Kaen University	1	3.17
Mahidol University	11	3.09
Prince of Songkla University	3	3.39
Silpakorn University	1	2.84
Srinakharinwirot University	1	3.45
Suranaree University of Technology	1	3.43
Thammasart University	12	3.18
University of Waterloo	1	Excellent Standing
Total	194	3.14

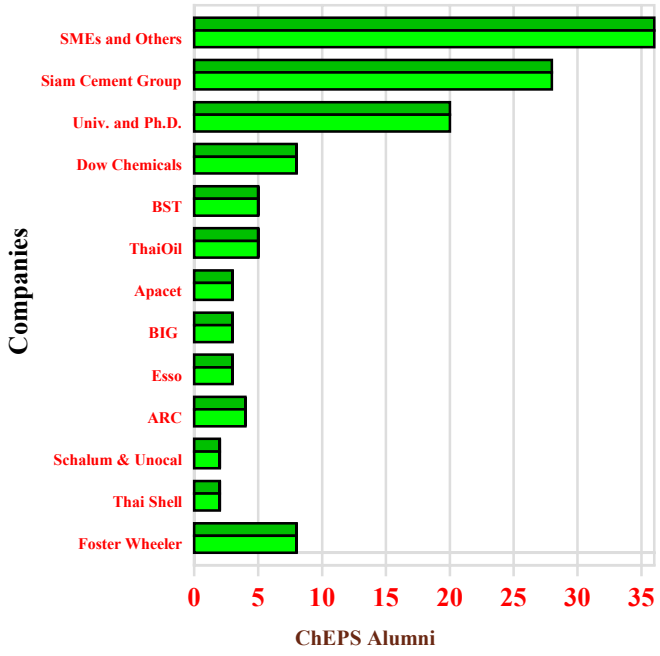

Figure 2. Employment Profile of ChEPS Graduates

ChEPS also conducts periodic surveys with site companies and employers of ChEPS graduates. The feedback so far has been positive, and preliminary data show that companies are generally happy with the performance of ChEPS graduates. The strengths of the ChEPS graduates often cited are good English proficiency, good presentation skills, self-confidence, and a short learning curve. The fact that most sponsoring companies continue to make their sites available is a testimony to the benefits and values of the practice school.

CONCLUSIONS

MIT in the US has successfully operated its Master's degree chemical engineering practice school for nearly 100 years. The uniqueness of the practice model lies in the industrial internship, which provides practical training for students. In 1997, KMUTT brought the practice-school model into Thailand as part of a reform initiative to improve the quality of its graduating engineering students and to better serve the needs of the industry. Thus, the Chemical Engineering Practice School or ChEPS was born. ChEPS incorporated the essential elements of the MIT model but was expanded to reflect the needs of Thai students. Problem-based learning and work intensity, together with industrial involvement, are the keys that drive the students to excel and contribute to the success of the program.

ChEPS is now in its 9th year since inception, and has since established a reputation as a premier chemical engineering program in the country. Each year, nearly 100 applicants compete for 24 openings. Admitted students are generally ranked in the top 10% of their graduating classes. Surveys have shown that companies sponsoring ChEPS believe the practice-school model to be a win-win partnership between the university and the private sector. The feedback from companies who employ ChEPS alumni is also generally positive.

The success story of ChEPS prompted KMUTT to extend the practice model to other departments, resulting in the creation of the Food Engineering Practice School (FEPS) [5], the Bioinformatics program (BIF) [6], and the Water Engineering Practice School (WEPS). There are now plans to establish more practice-based curricula in the fields of energy, bioengineering, and pulp and paper at KMUTT.

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