Operating a chemical engineering practice station

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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 Master's curriculum modeled after Massachusetts Institute of Technology's David H. Koch School of Chemical Engineering Practice [1]. The key components of the program are industrial internships and its strong linkage to the private sector. The success of ChEPS hinges on how to properly run a practice station where students receive their practical training. In this paper, steps and resources needed to operate a practice station, from making the first company contact, orientating students for their industrial training, to selecting projects and taking them to a successful conclusion, are presented. Moreover, the role of a site director dedicated to running a practice station and her responsibilities are highlighted. Finally, systematic methods for assessing the success of practice projects, from the perspectives of both the program and its industrial sponsors, are discussed. Ten years after its inception, ChEPS has become one of the top academic programs in Thailand, and is now a flagship curriculum at KMUTT.

INTRODUCTION

King Mongkut's University of Technology Thonburi (KMUTT) is an autonomous state institution in Bangkok with a long tradition in engineering. In recent years, the university has strived to augment its engineering programs with project-based learning (PBL) and a practice-school component. In 1996, KMUTT introduced a new practice-based Master's program called the Chemical Engineering Practice School (ChEPS) [2] [3] aimed at producing well-rounded engineers with strong technical expertise, good communication skills, and competent English proficiency. If proven successful, the goal was to expand the initiative to include other curricula.

The ChEPS curriculum consists of one academic year of coursework, one semester of industrial internship, and one semester of research, as illustrated in Figure 1. The ChEPS curriculum emphasizes both problem-solving and intensity. The uniqueness and success of the practice school lie in the practical training where problem-based learning is emphasized and students are constantly challenged to solve problems in real plants, sometimes with limited data and many constraints.

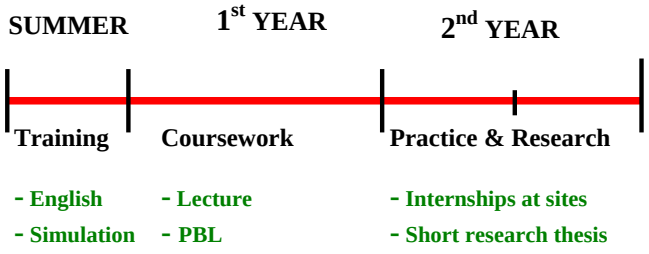

Figure 1. Timeline of ChEPS Curriculum

ROLE OF A PRACTICE STATOIN

Figure 2 illustrates the four essential components in the practice school, namely the university, the funding agencies, the students, and the industrial linkage. 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 ChEPS. Sponsoring companies allow ChEPS faculty and students to access their production facilities, also known as practice stations, which play a pivotal role in providing practical training for students. At the same time, sponsoring companies gain valuable human resources who can work on longer-term projects, thus freeing up company engineers to focus on more urgent needs. Consequently, maintaining this win-win partnership model between the university and the private sector hinges on the successful operation and implementation of practice stations.

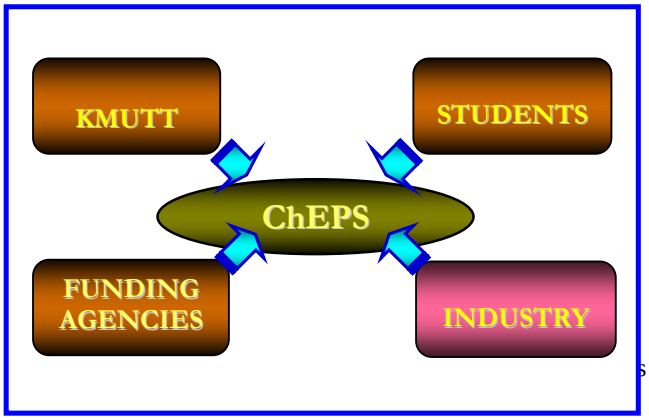

Figure 2. The Four Essential Components of ChEPS

PROJECT-BASED LEARNING

To better prepare students for their internships in the second year, ChEPS integrates PBL into some core courses. In most cases, these case studies, which tend to be too narrow in scope to be site projects, are solicited from sponsoring companies. The PBL introduced into the classroom mimics certain aspects of the site projects. The similarities are:

- Students work in teams of three or four people.
- Typical projects involve modeling, simulation, and optimization of chemical processes or systems.
- Regular oral presentations are scheduled to keep the faculty abreast of the latest progress.

Despite the similarities, one major difference between PBL and site projects is that, after an initial briefing by the sponsors, their involvement is kept to a minimum so as not to disrupt their routine work schedule. Instead, a ChEPS faculty is assigned to provide technical advice on a regular basis. Students are encouraged to use only emails to contact the sponsors for further input and clarifications. On the other hand, sponsors usually ask for one progress presentation. After ten weeks, a final presentation is held at the sponsoring company, by which time it will also receive a copy of the final report.

The use of PBL is a great way for ChEPS to network with the industries. In fact, not all case studies in PBL come from companies that serve as practice stations. In many cases, ChEPS is able to solicit projects from other companies through its alumni who work there. In addition, some companies are interested in sponsoring PBL because of the possibility of their becoming future practice stations. To these companies, sponsoring PBL is an ideal way to test-drive ChEPS and its practice model before more substantial resources are committed. Table 1 shows past contributors to ChEPS' PBL.

Company	Abbreviation
Alliance Refining Co., Ltd.	ARC
Rayong Olefins Co., Ltd.	ROC
Thai Oil Public Co., Ltd.	TOP
Thai Plastic and Chemicals Public Co., Ltd.	TPC
The Aromatics (Thailand) Public Co., Ltd.	ATC

Table 1. Companies Sponsoring ChEPS' PBL

OPERATIONS OF PRACTICE STATIONS

For the practice school to be successful, a sponsoring company must be completely committed to the partnership. This means that the company's staff at all levels must be brought in early in the decision-making process, beginning with the managing director, plant managers, engineers, all the way down to technicians and shift operators. The company's management sets the policy and allocates the necessary resources to run the practice station. But it is the engineers and operators with whom the students have to work daily. In other words, everyone in the company must be a firm believer of the practice school model and is totally committed to making it work.

Initially, the partnership between ChEPS and the companies are officially cemented through the signing of a memorandum of understanding (MOU) or a contract. The agreement spells out responsibilities of each party, expectations from each side, and details about financial obligations. For example, it is a standard practice for companies to offer in-kind contributions, such as office facilities, computers, and administrative support, and pay for housing of the practice team. In some instances, the companies pay monthly stipends to the students. In the past, ChEPS has been able to charge some companies consulting fees on the per-project basis as well. At any rate, each practice station is somewhat different. There is no fixed formula on cost sharing, which is dealt with on a case-by-case basis.

What distinguishes a practice school from a regular co-operative program is the presence of a full-time site director at a practice station. The site director is a faculty member who runs a practice station. In the first few years of ChEPS, the site directors received their training through mentoring and working closely with their counterparts at MIT's practice stations in the US for six months. In subsequent years, new site directors are trained in a similar fashion by spending a few months at ChEPS practice stations.

A few weeks before practical training is to begin, the sponsoring company will form an advisory committee, typically consisting of division heads, engineers and plant operators. The site director will then meet with this committee to identify projects and hammer out a detailed work plan. The duration of the practice phase is five months (one semester). Students work in teams of two or three on two projects in series (two phases), and take turns being the project leader. As a result, each project is ten weeks long, during which there are one proposal, one progress, and one final presentation. Figure 3 shows the working dynamics among the ChEPS faculty, the sponsoring companies, and the practicing students.

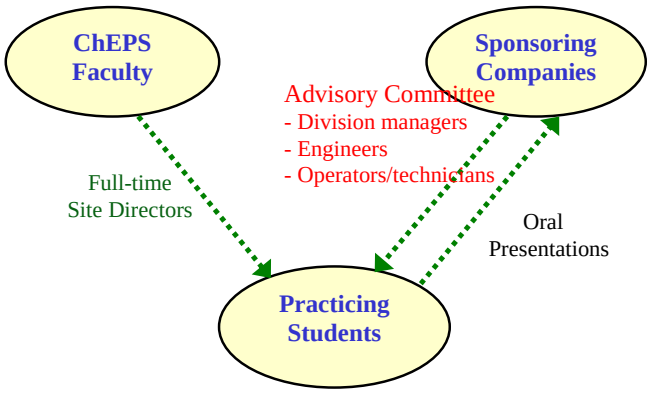

Figure 3. Working Relations in a Practice School

The operating procedure of site projects is outlined below:

- *Problem Assignment*
  The problem statement will provide students with background, motivations, and a list of objectives for the project. In addition, names of company employees who might be of help to the students are given. Also included in this document are possible solution methods and issues to consider which will help the students get started.
- *Project Planning and Organization*
  Since time is of essence in solving a site project, students must place special emphasis on planning and organizing the project. The first logical step is to investigate thoroughly the background of the given problem. Specific objectives of the project are then defined, followed by the scope of work and a systemic solution approach. It is interesting to note that information feedback is a vital part of this process, i.e. the initial plan of actions must be continually reviewed in light of the most current results.
- *Sponsors Meeting*

A meeting with station sponsors will take place one or two days after the problems have been assigned. This meeting is crucial and requires good preparation to ensure the students get a strong start on their projects. The group leader is expected to run the meeting. Progress meetings may be scheduled if such needs arise, e.g. when students run into serious obstacles or need to air major complaints.

- *Investigation Memorandum (IM)*
  All student groups are required to write a brief description of the problems and their solution approaches during the week after the problems have been assigned. Safety is an important part of the IM, and special attention is paid to sections on operational procedures and hazards of materials. The site director will review the first draft of the IM. Company sponsors will then comment on the document. Table 2 shows all the sections in an IM.

1. Background	5. Hazards of Materials
2. Objective(s)	6. References
3. Method of Approach	7. Work Schedule
4. Safety	

Table 2. Sections of an Investigation Memorandum

- *Proposal Conference*
  Shortly after the IM has been submitted, students will schedule a proposal presentation with the sponsors, in which objectives and a detailed solution methodology will be presented. This is an important forum for sponsors to ask tough questions and critique the proposed work. By this time, the students should have familiarized themselves with the appropriate theories, previous experimental work if any, and other relevant technical information.
- *Progress Report*
  Each project will have a mid-phase oral presentation in which the students update the company with the general status of their work, including what is planned.
- *Final Report*
  The final oral presentation and report complete the engineering work. The final report should clearly state the conclusions and recommendations. The body and appendices of the report should also include sufficient technical materials and data for other engineers to duplicate or verify the students' findings.

Because of the remote geographical locations of all practice stations, the site director and the practicing students can feel isolated from those at the university. The many site oral presentations provide an ideal forum for everyone to meet up and exchange ideas. ChEPS faculty on campus will travel to the site to attend the site presentations. In addition to being an opportunity for other faculty to provide more input, this participation by those at KMUTT signifies to everyone that the program places a lot of importance on the site projects. As a result, these presentations become more formal and well attended, and the enthusiasm on all sides is higher. Table 3 shows a list of all practice stations in the ChEPS program.

Practice Stations	Years
Thai Oil Public Co., Ltd.	1998 - 2006
Thai Polyethylene Co., Ltd.	1998 - 1999, 2001
BST Elastomers Co., Ltd.	2001 - 2002
Rayong Olefins Co., Ltd.	2002 - 2003, 2006
The Aromatics (Thailand) Public Co., Ltd.	2002 - 2005
Siam Mitsui PTA Co., Ltd.	2003

Table 3. Past and Present Practice Stations of ChEPS

SELECTION OF SITE PROJECTS

A lot of thoughts must go into picking the right projects for practical training. First and foremost is that the projects must be educational for the students as well as useful for the company. The internship is equivalent to one-half a Master's research thesis, or six credit hours. As such, students are expected to work long hours and submit a large amount of written documentations. An ideal ChEPS site project should contain the following three elements:

1. Avenue for applying theoretical analyses
2. Opportunity to carry out lab-scale work and simulation
3. Validation or applications to actual operations.

In the first criterion, the projects should contain sufficient technical aspects conducive to being solved by theories and analytical methods. The students will review the literature and formulate a solution methodology. The second criterion provides students with an opportunity to work with equipment, design experiments, and collect data. With modeling and simulation, the students learn how to use sophisticated software packages to solve complex problems. Finally, the last criterion allows the students to apply their results and recommendations.

Obviously, not all projects will meet the stringent standard outlined above. However, the more of these elements are incorporated into a project, the better. The single most important aspect that must be present in all site projects is the "hands-on" work set in an industrial environment. For example, a project which requires students to develop a simulation model for a process could be a good project, despite missing the lab component, if the students are asked to sample data from the actual process or are allowed to validate their findings based on actual process data. In addition, the projects must be amenable to the ten-week timeframe. Longer projects may be divided into smaller parts to be completed sequentially.

ROLE OF SITE DIRECTORS

The site director is a ChEPS faculty member who holds a PhD degree in chemical engineering or chemical technology. Prior industrial experience, while preferable, is not required. The important role of the site director cannot be over-emphasized. The site director drives the practice station, interacts with industrial sponsors, and work closely with students in nearly all aspects of the site projects.

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 site director has the following specific responsibilities:

- *Identify projects* – The site director must work closely with the industrial sponsors at the outset to identify potential site problems. Here, the site director's main job is to screen the proposed projects and ensure that the ones chosen do contain academic values. For example, asking students to survey existing tray types because the company wants to design a new distillation column may be of interest to the sponsors, but the project offers little technical value from which the students can learn.
- *Prepare a working timetable* – The site director is responsible for forming student groups and planning a work schedule that includes all the presentations.
- *Provide technical advice* – While the students rely on company sponsors for their technical expertise and advice, the site director should be able to advise students on the more general technical issues. The frequent meetings allow company engineers and the site director to exchange ideas and learn from each other.
- *Review and edit reports* – The site director is expected to spend a great deal of time reading and editing students' reports. Since all written documentations are in English which is not ChEPS students' native language, the site director must also edit grammar and diction in all reports. Moreover, the site director ensures that all oral presentations go smoothly by reviewing students' presentation slides and listening to their rehearsals.

Because of her close proximity, the site director has more access and more opportunities to see the sponsors. Although not her main job function, it is customary for the site director to elicit research topics from the sponsors as ChEPS theses to be carried out in the second year. These individual research problems, which tend to be too big to be site projects, may be advised by any faculty in ChEPS including the site director. This joint research adds another dimension to the collaboration between the practice program and the company.

PROJECT ASSESSMENT AND CHALLENGES

An objective assessment of site projects after their completion is crucial and is an integral part of the practice school. This documentation helps students identify their areas of weakness. At the same time, sponsors also use this evaluation to document the impact of the students' work and convey the findings to the senior management, who will decide if follow-up studies or implementations of the proposed ideas are warranted. Moreover, some financial supporters of ChEPS requires that the program submit the findings, often in the form of short abstracts, to demonstrate how their funding benefits the chemical and petrochemical industries, e.g. in reducing energy consumptions or boosting the industries' competitiveness.

The assessment of site projects is divided into two parts. The first is the evaluation of the students' performance. Typically, the students are judged in the following four categories:

1. Problem-solving approach
2. Accuracy and completeness of work
3. Presentation skills
4. Command of English including final reports

There are four ratings in each category, namely Excellent, Good, Fair, and Poor. Some site directors prefer to conduct a student evaluation right after the presentation, in which each student presenter is critiqued by her peers.

Site directors then work closely with the sponsors in the second part to evaluate the overall success of the projects. The criterion is usually the amount of money the company can save if recommendations in the study are implemented. Further calculations may be needed here, since not every project will contain cost-saving analyses. It should be noted that ChEPS is not privy to this information, as such data are considered confidential by the company. An educated guess on the total annual savings based on typical numbers seen in a project is on the order of 50 million baht per year (0.14 M US dollars). This number is based on the assumption that the practice station operates in both semesters with a total of 16 projects.

Running a practice station also entails many challenges. First is the difficulty of recruiting faculty to become site directors, as most prefer to focus on their research. Monetary compensation and the chance to network with industries are the key incentives. Also, it was found that younger and new faculties are more likely to agree to move to the site because of the need for industrial exposure. Second is the expense in terms of time and money in transporting ChEPS faculty to the remote practice sites to attend the presentations. Since these forums occur fairly frequently, finding someone to travel to the sites each time can be difficult. Moreover, since starting a new practice site is a lengthy process, ChEPS prefers a long-term commitment from a sponsoring company. Some companies are reluctant to do so because of the cyclical nature of the petrochemical industry and concerns about exhausting all the available projects. Finally, it is always a challenge to negotiate an appropriate fee and contributions a company should put into sponsoring a practice station and a practice team.

CONCLUSIONS

KMUTT has successfully operated the practice-based ChEPS program for 10 years. The uniqueness of the practice model lies in the industrial internship, which provides practical training for students. Effective and efficient management of practice stations is the key to successfully running the practice school. In this paper, the operating procedure for running a practice station, the role of the site director who drives the practice station, and an assessment to quantify the impact of site projects are discussed.

Ten years after its inception, ChEPS has established a reputation as a premier chemical engineering program in the country. 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.

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