

An Approach on Integrating Cooperative Education Experience into the Engineering Curriculum

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Abstract—The center/unit for industry engagement and collaboration, as well as Internship, plays a significant role at a university. In general, the Center serves as the official interface between industry and the school or department to cultivate students' early exposure to professional experience. The missions of the Center are not limited to provide a communication channel and collaborative platform for the industries and the university but also to assist students to build their career paths early while still at the university. In recent years, a cooperative education experience (commonly known as a co-op) has been strongly advocated for students to make the school-to-work transition. The nature of the co-op program is not only consistent with the internships/final year design projects, but it is also more industrial-oriented with academic support from faculty at the university. The purpose of this paper is to describe an approach to how cooperative education experience can be integrated into the engineering curriculum. It provides a mutual understanding and exchange of ideas for the approach between the university and industry. A suggested format in terms of timeline, duration, selection of candidates, students, and companies' expectations for the co-op program is described. Also, feedback from employers/industries shows that a longer-term co-op program is well suited for students compared with a short-term internship. To this end, it provides an insight into collaboration and/or partnership between the university and the industries to prepare professional work-ready graduates.

Keywords—Cooperative education, internship, industry collaboration, engineering curriculum.

I. INTRODUCTION

UNIVERSITIES continuously provide different learning experiences for students to enhance their capabilities for better understanding and engagement. Apart from gaining knowledge and skills from university, students are also encouraged to participate in non-campus activities, such as student competitions, internships and industrial engagement. These activities assist students to explore their interests and develop critical thinking and essential communication skills [1]. Nowadays, students benefit from numerous types of innovative pedagogies including student-centered [2], project-based/problem-based [3], experiential learning [4], blended learning/flipped classroom [5], Massive Online Open Course (MOOC) [6], etc., in the current higher education system.

In the fast-changing job market, technologies and competitiveness together with global environment urge universities to face challenges of equipping students with the knowledge and skills required to solve complex real-world problems. In fact, the capability to identify both complex problems and the corresponding solutions in their daily lives is

one of the criteria/skillsets required for graduates to obtain their careers at professional organizations and companies [7]. In order to improve the employability of graduates, the performance and approach of university education must be enhanced. Project-based industry placement can play an important role of university-industry engagement in which the main goal is to broaden the professional interests of a particular discipline and the exposure of students. Also, problem-solving and hands-on skills can be gained through tackling complex or ill-structured work challenges in the workplace [8]

In recent years, the cooperative (Co-op) program has been highly promoted as another form of university-industry engagement. Students are advised by an industrial supervisor to complete experiments, reports, presentations, tasks, etc., as a regular employee would do. Meanwhile, students are required to meet their academic supervisor/faculty for reporting the tasks they have completed in companies, ensuring the student gains the knowledge and skills via the co-op program and meets the requirements for graduation. It has been reported that co-op has been a part of the engineering program since its inception in 1957 [9]. It offers students real-life practical working experience in their field of study outside the traditional academic setting. Through Co-op, students can broaden their horizons, enrich their knowledge in working environments, sharpen their communication and time management skills, and start building a network of contacts for future development.

On the other hand, industry, which consists of companies and organizations of all sizes, can benefit from engaging students as fresh brains for a cost-effective intellectual investigation of new/on-going projects. Students can provide valuable insights that are not bound by experiences and manpower to work on the projects. The collaboration between students and existing staff would enhance the quality of the final products. The Internship/Co-op program offers the best solution to the companies' recruitment exercise. By offering students the chance to be part of the company/organization for a period during when assessment can be made, the business/organization minimizes potential risks and losses from hiring wrong talents. The employer can extend the engagement with potential candidates by offering students graduate opportunities.

It was reported that employers need graduates who can help them deal with change and it is not enough for higher education institutions to simply list the skills they have developed [10]. However, collaboration between university and industry is complex, successful industry placement engagement requires champions from both sides as the driving force. The purpose of

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this paper is to describe an approach of integrating a cooperative education experience into the engineering curriculum, particularly in the Department of Mechanical and Aerospace Engineering (MAE) at the Hong Kong University of Science and Technology (HKUST). A suggested format in terms of timeline, duration, selection of candidates/matching process, students' participation, and expectation of industries for the co-op program is described, according to the mutual understanding between the University and the industries. To this end, a number of students' feedback are also provided to support the benefits of participating Co-op/internship related programs.

II. APPROACH

The University aims at training graduates' ability to meet the demand of most of the engineering jobs and prepare the graduates as work-ready as possible. The Co-op Program is one of the possible, comprehensive and qualitative options for work-integrated learning under our tertiary education system. The Co-op Program has become an official option as a graduation requirement to substitute the final year design project (FYDP) for undergraduate students in the Department of MAE at HKUST.

A. Timeline and Duration

The program offers opportunities students to work as a full-time intern in a company either for a term long (i.e., 5-6 months) or a year-long program. Generally, the potential Co-op partners are invited by the department to join the program in the middle of December every year. In this case, students are expected to commence their work next year after in January (e.g., Co-op partners are invited to join the program in December/2021, and students are expected to commence the work in January/2023). It should be noted that the Co-op program is designed for final year students who have completed all credits required for graduation requirement before commencing their work in the company, such that students could focus on the project and tasks assigned. Students are then given a specific topic according to the business/nature of the companies and organizations. The actual working periods are typically scheduled from February to June; however, some projects are started in January during the winter break. The department invites participation from industry to ensure the program is a positive experience for the participating students.

B. Selection of Candidates/Matching Process

By middle of January in the following year, i.e., 2022, the Department is required to call for students' application for the program. At the end of January, applications would be collected from students. During February, the Department would contact the co-op partners and start the selection process, including resume review and student interviews. Meanwhile, the potential partners are required to provide a project topic and description to the Department for further matching in order to avoid any misalignment. The interview results together with the confirmed Co-op offers are released to students from late March to May, according to numbers of screening processes, applications and interviews, etc.

C. Students' Participation

Since the Co-op program has been designed as one of the graduation requirements to replace the FYDP, final year students would participate for the Co-op program typically from February to June in the last term, i.e., Fall term in the final year. However, it might be varied depending on the term long or the yearlong program stated in the previous section, namely Timeline and Duration. The participating students are expected to gain at least 5-months industrial and work experience. They are provided for an opportunity to engage a real-life industrial project proposed by the matched company under the supervision of two supervisors (one from the company as an Industrial Supervisor, the other one from the student's academic department at HKUST as the Academic Supervisor). Participates are expected to gain specific knowledge in the industry and obtain first-hand experience in engineering related projects.

D. Expectations of Industries

It has been well documented in the literature that industries expect work-ready graduates to commence and take up the assigned projects or tasks as fast as possible [11]. The competencies expected of graduates include not only professional and technical knowledge, but also interpersonal, communication and problem-solving skills. Moreover, capabilities to work either individually or in teams would be desirable. Co-op partners would have similar expectations from the participating student to engage in the Co-op project assigned. It is interesting to note that industries' preferences are to offer a comparatively longer period for the Co-op program which resembles an internship. In fact, it provides sufficient time for student to complete the project. On the other hand, students would become proficient with the task and accustomed to the routine exercises. One of the Co-op partners states that the Co-op program is a valuable experience for students to gain hands-on skills apart from the theoretical knowledges obtained from textbooks. Students would have opportunities to improve their communication and interpersonal skills by interacting with different industrial people.

E. Assessment and Evaluation

Similar to a regular course, a letter grade is given ranging from A+ to F, where an A+ is a distinction and an F is a fail. Co-op students are required to meet with their academic supervisor, either via online platform or face-to-face meetings at the university at least twice a month. The purpose of meeting with the academic supervisor is to report the progress and to seek advice on their project if any difficulties and challenges are encountered. It should be noted that Co-op program is not only beneficial for students to gain practical experience, but also for the company/organization to explore the possible solution/collaboration with academia. On the other hand, students are needed to submit two reports for the Co-op program. The first one is a progress report which should be submitted after six weeks of commencement in the company. The second one is the final report which should be submitted before the final presentation is scheduled. The final presentation

is arranged for the student to present their project in detail, including introduction, objective, methodology, results, discussion, and conclusion, to the industrial and academic supervisors as well as the departmental co-op/internship coordinator.

Students are evaluated according to a number of suggested performance criteria listed below:

- i. Problem identification and solution approach: 10%
- ii. Project organization: 5%
- iii. Design methodology: 15%
- iv. Achievement: 40%
- v. Report writing and presentation: 15%
- vi. Teamwork: 15%

The above performance criteria with suggested percentages can be adjusted according to the needs for designing a particular Co-op program. Clear rubrics can support consistent grading for the course with multiple grades.

III. STUDENTS' COMMENTS

A student studying BEng in Mechanical Engineering commented that:

'My 5-month Co-op internship program is underway in CLP. I am conducting the feasibility study of burning hydrogen in existing Black Point Power Station Gas Turbines. I joined the program for dodging my FYP at first, but I am so delighted that the Co-op internship experience has been out of my expectations. The frequent site visits to the power plant reminded me of the engineering knowledge I learnt from UST and brought me additional insight into the power generation process which can only be gained via first-hand experience. Participating in the outage project gave me a profound sense of accomplishment. After interacting with a range of stakeholders, such as participating in a meeting with an external company and discussing outage details with a German specialist, I gained a better understanding of the engineering sector. The Co-op program is one of the best experiences UST has granted me. This internship not only offers me practical experience but also inspires me to contribute to the engineering profession in the future.'

A student enrolled in BEng in Aerospace Engineering pointed out that:

'Growing up loving aircrafts and being innately curious it was a no-brainer for me to choose Aerospace Engineering as my major when it came to higher education. As expected, the courses I took here were engrossing from Aerodynamics to Jet Propulsion, it was what I wanted to learn but at the end of the day, it is still just theory. However, it was through my Co-op internship where I got hands-on experience on engineering projects. Being around such complex machines every day at the hangar could be overwhelming, but the learnings and experience from it is truly second-to-none. With this golden opportunity, I am able to say that the sky is definitely not the limit.'

His fellow classmate added that:

'In this Co-op program, I had the opportunity to be

exposed to how a battery research organization works. The actual works involved the fabrication of various kinds of batteries (coin/pouch cells) for different purposes (fast-charging/high power etc.) and the testing data collected can be used for the calculation of typical battery performance indicators, such as specific power, energy density etc. I was also involved in the coating of cathode active materials to determine the effects of increasing nickel content. I was also engaged in designing a formation profile to determine how the profile will affect the SEI formation. This whole program also served as a learning process and stepping stone for my future goals as I would like to develop an all-electric commercial aircraft to reduce the greenhouse effects brought by the aviation industry, combining my knowledge in the battery industry and in aerospace industry, which is my current major.'

A penultimate student who took up four internships in 3 years remarked that

'Participating in internships allows you to explore your career choices, and also gain hands-on experience on projects. I acquired various essential skills for a graduate job during my internships.' Another student echoed that statement by saying that, 'Working closely with internal stakeholders, in-house technology partners and external vendors, I developed strong communication skills. The internship experience was extremely rewarding as it provided me with loads of in-depth and hands-on knowledge in the financial sector. It better prepared me to enter the banking industry after graduation.'

A student reflected on his internship experience and found that:

'On the first day of my first internship, my mind was racing with possibilities, having no inkling or previous experience to realize what to expect from this job. On the last day of my first internship, my mind was racing with possibilities, now armed with the experience to realize that there was a whole world of opportunities waiting for me.'

Another student concluded with:

'I will be joining (the company) full-time after graduation and am excited to share my unique edge of technical and business understanding. During the internship, I was able to bridge the theoretical concepts of software and hardware applications to real world problems and interact with clients to find the best solutions. I am grateful to the school for having the Internship program!'

IV. DISCUSSIONS

There are no doubts that students' engagement in professional work experiences through Co-op/internship related programs creates multidimensional benefits to student, university and industry. These programs have been demonstrated to provide students a chance to obtain practical work experiences during their studies in preparation for their future careers. Furthermore, these work experiences enrich students' knowledge in a real-life work environment, broadens their horizons, sharpens their communication, interpersonal and time management skills and allows them to build up a network

of professional contacts [8], [9].

By placing students in Co-op/internship opportunities, the university offers a practical course to train its students from taking to giving. Students are used to taking something from their teachers, advisors and educational institutes such as knowledge from a professor's lecture and advice from career advisors etc. Students would have to take up another role once they step into the hiring company/organization as a workforce [3]. They are expected to give by providing services to their employers. After all, they are paid by their employers to contribute. While the university can provide simulation exercise or practical training, the authentic real-world environment offers challenges that cannot be mimicked.

From the feedback collected from employers, the university would have a better and up-to-date understanding of the current practices and needs of the industry, find out the strengths and weaknesses of its current offerings and be able to refine its programs and curriculum design accordingly. The employability of graduates is one of the parameters to measure a university's success, the institute can improve the employability of its students by aligning with industry to offer students structured Co-op/internship opportunities.

Given the advantages, the university and industry should take a proactive approach in creating structured Co-op/internship programs for students. The university and industry should treat each other as partners and work collectively together. The two sides should conduct regular meetings to review and plan for future collaborative programs and projects. They should invite students to provide feedback and suggestions for improvement.

V.CONCLUSION

An approach of integrating a cooperative education experience into the engineering curriculum with a suggested format, including timeline, duration, selection of candidates, students and companies' expectation, assessment and evaluation was described. A number of students' comments were collected to reveal that the cooperative program has offered opportunities not only to gain practical experience, but also to contribute themselves to the engineering profession in the future. Also, these practical experiences were given to enrich students' knowledge in a real-life work environment, broaden their horizons, sharpen their communication, interpersonal and time management skills and allow them to build up a network of professional contacts. Furthermore, the university would have a better and up-to-date understanding of the current practices and needs of industry, in order to find out the strengths and weaknesses of its current offerings and be able to refine its programs and curriculum design accordingly.

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