Article Type: Spec. Iss. on Software Engineering Education & Tr

Education with Experience: Assessment of a Co-op Model in Undergraduate Engineering Programs in Computing

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Abstract*— A major concern among graduates of computing departments has been the discrepancy between the expectations of the software companies and the competencies provided by the respected departments. This ongoing problem, paired with rapid developments in computing, makes cooperative (co-op) education inevitable as it combines industrial experience with traditional education. The present attempt examines the co-op program conducted for the past 4 years at the Computer, Software, and Information Systems Engineering Departments of Atilim University, Türkiye. It assesses the attainments of the stakeholders of this co-op program, mainly students, academic institutions, and partner companies, in terms of product/project, familiarization, career, and employment opportunities. The results of the surveys conducted among students and partner companies participating in the program are given, demonstrating various benefits to all stakeholders.

There is an ongoing debate on the misalignment between the work-based skills expected by the industry and the competencies provided by engineering education, especially in the area of computing. It is argued that even if the curricula of the departments are well-designed in such a way that they balance theoretical knowledge with practice through laboratories, projects, and short-term internships, students still need to gain engineering practice at the workplace for a longer period [1]. Moreover, one of the main objectives of universities and companies is to increase the employability level of new graduates – an issue which has been otherwise defined as ‘‘skills, knowledge, attitudes and commercial understanding that will enable new graduates to make productive contributions to organizational objectives soon after commencing employment’’[2]. Upon graduation, students tend to seek a variety of employment opportunities; whereas, companies look for graduates with previous experience and no need for additional training. As a solution to these problems, co-op education, which is a form of work-integrated learning, has been gaining interest for the past few years both from higher education institutions and companies [3].

Co-op education was first introduced in 1906 at the University of Cincinnati, U.S.A., to combine traditional education with industrial experience and provide a form of experiential learning [4,5]. Co-op programs can be conducted at universities, either as full-time alternating intervals between school and work or as a part-time combination of school and work, supervised by a professional from a partner institution [4]. There have been numerous benefits reported for this type of structured

work experience during undergraduate studies for students, companies, and higher-education institutions alike.

To start with, from the students' perspective, their motivation, self-confidence, and understanding of their future career are enhanced [6], practical knowledge of work-based skills is gained, and employment opportunities are increased [7]. From the perspective of the industry, recruiting new graduates is simplified significantly [5], their transition to the workplace is facilitated [1], and the visibility of the company is increased [6]. Finally, collaboration with partner companies enables universities to become more aware of the problems and practical needs of the industry, eventually leading to curricular improvements [6]. Previous studies have shown that the only factor that makes a significant difference in the employability of graduates is 'structured work experience'[1,2].

In recent years, there have been various research studies conducted on co-op education. An experiential learning framework has been defined for computer science programs to incorporate experiences and enhance soft skills, real-world focus, group and individual work, and student empowerment [8]. In their study, Erdem and Toklu present a conceptual model for a co-op education program using a management information system [4]. Other international co-op programs have been conducted at the University of Technology, Jamaica [5], the Shanghai Institute of Technology [9], the Electronics and Information Research Centre, Brazil [10], and the University of Ottowa [11], and overseas cooperative education programs have been introduced in the U.S., Canada, Britain, Germany, and France [12]. In a separate work, Johanyák [6] shows the benefits of real-world software projects to students, companies, and academia. In their study, Nevison et al.[3] analyze the relationship between the students' perceptions of a co-op learning environment, the meaningfulness of their work, and the perceived relatedness of the work experience to their future professions and academic studies. Moreover, Nabi et al.[13] have designed a Work Based Learning module for a Software Engineering program with the objective of meaningful and motivated learning. Also, Khakurel and Porras [14] examine the effects of working on a real-world project on the acquisition of soft skills for Software Engineering students. Finally, three international co-op programs are presented in the study by Maguire and Cutts along with a description of the history of software engineering education [15].

While there have been previous studies describing various frameworks used in co-op programs, to the best of the authors' knowledge, only a few have introduced the actual components of such a program together with an evaluation of the results pertaining to the participants. Unlike the previous studies, our co-op model incorporates assessments from both the company and students' perspectives. To fill this gap, in this study, we present in detail the co-op program conducted for the past four years at the Computer, Software, and Information Systems Engineering Departments of Atilim University, Türkiye, together with a complete investigation of the survey results carried out among the participating students and software companies. The outcomes of the present work are believed to provide significant feedback to higher-education institutions and companies that are indecisive about offering co-op programs, as well as help such institutions come up with a detailed road map for establishing such programs in the existing curricula.

AN EXTENDED MODEL OF CO-OP EDUCATION AT ATILIM UNIVERSITY

Since 2020, Atilim University, a foundation establishment, in Ankara, Türkiye has been offering a non-obligatory co-op education program for the undergraduate students of the Computer, Software, and Information Systems Engineering Departments at the School of Engineering. The "Co-op Education Program" consists of 6 to 7 months of uninterrupted workplace training held at partner companies by combining the summer internship with the succeeding Fall semester (7th term of the curriculum). In Türkiye, the duration of the undergraduate engineering programs is eight semesters. Engineering departments running a co-op program commonly choose a 3+1-year or 7+1-semester model [4]. The co-op education model here adopts an extended version of the 7+1-model and includes seven months of training in the form of 7 semesters at university + Summer internship at the company + 1 semester at company.

A student can enroll in this program only after completing all of the courses in the first six semesters with a GPA of at least 2.00/4.00. They can apply to the program in the middle of the Spring semester by providing a list of potential partner companies that they wish to co-op with. The career planning office responsible for co-op activities conveys this list of preferences to the human resources departments of the named partner companies.

Students who are accepted to the program register for summer internship (10 ECTS - European Credit Transfer System) and a set of courses (26 ECTS) that

involves two technical and two non- technical elective courses, and a Senior Project. The department and partner company separately appoint a mentor for each co-op student who is responsible for guiding and evaluating her/him

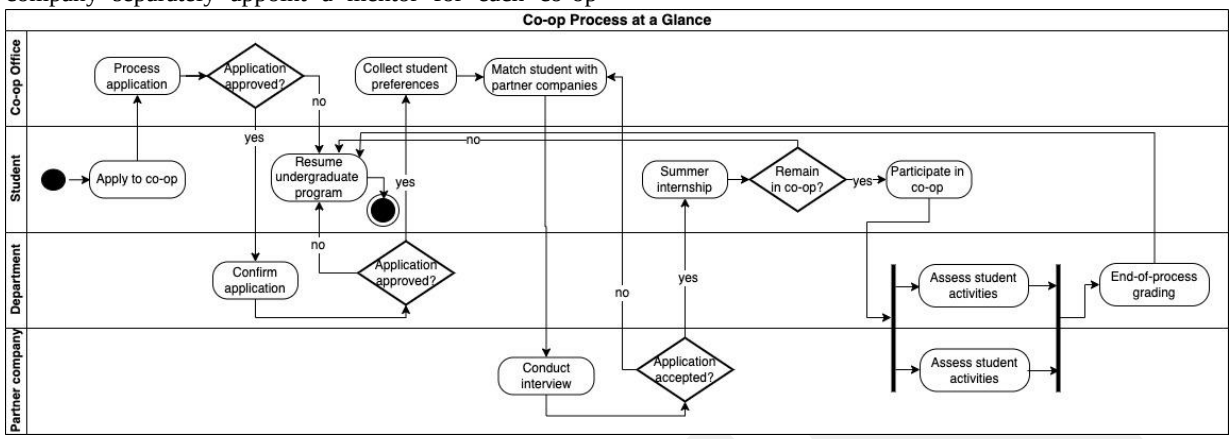

FIGURE 1. Co-op process swimlane diagram

throughout the program starting with the summer internship. During the implementation of the program, students are expected to participate in social activities, online and face-to-face training, and fulfill the technical tasks assigned by the company mentor. All these activities, along with summer internship and related internship reports, student poster/project presentations, and reports are used in the assessment of the summer internships and courses that account for the 7th semester (26 ECTS).

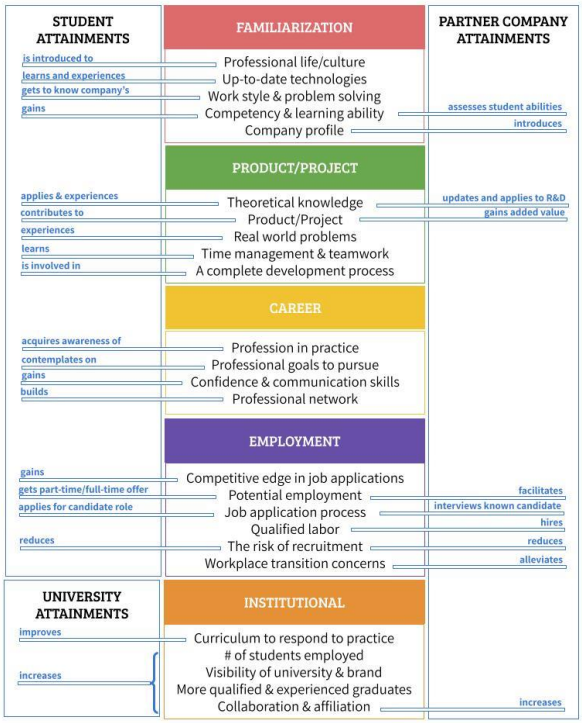

FIGURE 2. Co-op program attainments

This co-op process, as depicted in Figure 1, leads to a diverse set of attainments from three parties, namely the student, partner company and university, as depicted in Figure 2. As can be seen, acting as a medium between students and partner companies, the university also has gains from this partnership.

ASSESSMENT OF THE CO-OP MODEL

The co-op model is evaluated by collecting assessments and feedback from the partner companies and students separately. A total of 54 evaluations from 13 partner companies working in diverse domains ranging from defense to health, and 62 evaluations from students were collected between 2019 and 2022. For the student evaluations, a 5-point Likert scale is used to assess the co-op program, while for the companies, assessment is performed with open-ended questions.

Table 1 gives a summary of information about the co-op program in place. In total, 73 students were enrolled in the program, and a total of 38 companies signed a protocol with Atilim University; seventeen of these companies actively participated in the program. It is worth mentioning that the number of partner companies signing a protocol and participating in the program has been increasing each year, except for 2020-2021 probably due to the pandemic. The increasing trend is also evident in the number of students enrolled owing to the introduction of the co-op program by their instructors, word of mouth among students, and poster/project presentations.

Table 2 provides the findings related to employment based on partner company and student evaluations in the 'Recruitment' and 'Offer' columns. The fluctuations in the rate of recruitment may be due to the fact that while some of the mentors in the partner company have recruitment authority as they work at executive levels,

TABLE 1. Co-op program at a glance.

Term	# of partner companies	# of participating partner companies	# of students	Increase in # of student enrollment by year
2019-20	22	5	9	-
2020-21	25	4	13	%44.4
2021-22	36	5	19	%46.2
2022-23	38	9	32	%68.4

others can only recommend the students as 'strong candidates' to upper levels. It is observed that the percentage of 'strong candidates', which can be considered as a predecessor of recruitment, has been on the rise over the years. All of the students were evaluated as "successful" (implying that the individuals have fulfilled the requirements) by their company mentors, and only two students were recommended to improve their soft skills.

An initiative called the "candidate engineer program" has been on the agenda of certain companies that signed up with the university. During the co-op education, students were able to apply to this program, especially with in-house references from their mentors. As such, participation in this program and being referred by mentors are two factors that most likely increase the chance of recruitment. The companies that have recently joined the program accept the applicant students as candidates for 6 months to assess their competency, and technical and soft skills. Put together, these have a profound effect as they reduce the risk of recruiting an unproductive applicant. The findings of the student evaluations ('Offer' column, Table 2) show that each year, more than 50% of the students (on average 62.9%) found the opportunity of being recruited by a company that they had already been familiar with. Moreover, most of them were rated as 'strong candidates', even if they did not receive an official offer.

TABLE 2. Findings for employment based on partner company and student evaluations.

Term	Recruitment *From Partner Company Evaluations*	Offer *From Student Evaluations*
2019-20	Recruited: 11.1% Strong candidates: 33.3% No response: 55.5%	55.6 %
2020-21	Recruited: 15.4% Strong candidates: 46.2% No response: 38.5%	61.5 %
2021-22	Application submitted: 5.2% Application in progress: 10.5% Strong candidates: 65.2% No response: 21.1%	52.6 %
2022-23	Application submitted: 3.1% Strong candidates: 75% Not a candidate: 3.1% No response: 18.8%	50 %

The company evaluation consists of two parts, namely, the student assessment from the perspective of the company and the company attainments based on the following open-ended questions:

- How do you assess the overall contribution of the student to your workplace (based on your own criteria)?
- Please share your opinions regarding the co-op program.
- Do you consider recruiting the student part-time or full-time, either during their studies or after graduation?

It has been observed that all of the partner companies have a positive attitude toward the co-op program, which the university aims to improve based on the feedback given for the upcoming semesters. From the company's standpoint, the co-op program allows the company to assess the competency and learning abilities of students, streamlines the job application process through interviews with known candidates, facilitates potential employment, reduces recruitment risks, and provides access to qualified labor. The opportunity for companies to familiarize themselves with the students positively affects the employment process. Besides, students' contribution to company projects adds value to the companies by bringing new perspectives.

Several significant student attainments have been identified by the companies. These include the students' introduction to the professional work environment and culture (Familiarization), their practical experience in

solving real-world problems (Product/Project), and the acquisition of practical awareness of their profession (Career). The identification of these attainments emphasizes the effectiveness of the co-op program in preparing students for the professional world.

Table 3 demonstrates the student attainments based on their own evaluations. The survey questions can be found in the sidebar. The distinctive attainments for students (higher than 4.5 on average) are focused on technical skills (learning and experiencing up-to-date technologies) and more on soft skills (gaining competency and improving learning ability, learning time management through task assignment and experiencing teamwork, and gaining confidence and improving communication skills).

TABLE 3. Attainment assessment based on student evaluations.

Category	Student Attainments	Questions	Average (max. 5)
Familiarization	Professional life/culture	Q1, Q9	4.43
	Up-to-date technologies	**Q8**	**4.56**
	Work style & problem solving	Q1, Q9	4.43
	Competency & learning ability	**Q4**	**4.63**
Product/Project	Theoretical knowledge	Q2, Q3	4.43
	Product/Project	Q1	4.40
	Real-world problems	Q1, Q8	4.48
	Time management & teamwork	**Q6**	**4.58**
	A complete development process	Q1	4.40
Career	Profession in practice	Q8, Q9	4.51
	Professional goals to pursue	Q1, Q4	4.52
	Confidence & communication skills	**Q5, Q7**	**4.58**
Employment	Competitive edge in job applications	Q1, Q4-9	4.53

Ultimately, the findings related to student evaluations are used in the decision of whether to continue with a partner company in the following years. In the same way, the feedback about the students received from the mentors at the companies could be used in revising the curricula to increase students' employability levels.

CONCLUSION

The present work introduces in detail a new model for a co-op program conducted at Atilim University, and attests to the diverse benefits of the program in terms of participating students and companies through surveys. The findings will hopefully give insight to higher-education institutions and the industry that would like to collaborate toward incorporating structured work experience into potential employees' background and the curricula that prepares them for this purpose.

One of the limitations of this study is the lack of institutional assessment. Consequently, to begin with, the attainments of higher-education institutions through co-op programs can be investigated in future studies. Next, an assessment framework can be implemented to quantitatively evaluate the attainments of the program. Furthermore, one may increase the number of partner companies and student participation, in this way, generate a larger pool of results to be used in the program assessment. Additionally, the existing model can be adapted to the companies that promote working remotely from home.

Finally, this study focuses only on the co-op students studying in the computer, software, and information systems engineering departments. Therefore, the same analysis can be applied to similar programs of other departments in order to account for a comparative analysis. As a longitudinal study, this research can be further extended to follow up on the career of the participating students after graduation.

ACKNOWLEDGMENTS

We are grateful to Selin Tefil, Director of Career Planning and Cooperative Education Office at Atilim University, for providing essential data to effectively conduct this study.

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SIDEBAR

Survey Questions in Student Evaluation

Q1.The graduation project in the co-op program contributed to my professional development.

Q2.The studies on the Area Elective courses in the co-op program were sufficient.

Q3.The studies on the General Elective courses in the co-op program were sufficient.

Q4.I acquired technical and social professional competencies in the co-op program.

Q5.The co-op program has helped me improve my human relations.

Q6.The co-op program helped me develop my team working skills.

Q7.The co-op program helped me express myself and communicate effectively.

Q8.In the co-op program, I had the opportunity to practice the up-to-date technical information that I will use in business life.

Q9.The co-op program prepared me for business life.