International Journal of Engineering Education Vol. 38, No. 4, pp. 1056–1072, 2022
Printed in Great Britain

0949-149X/91 $3.00+0.00

Managing the Industrial Engineering Cooperative Program Process Using a Standardization Process Model*

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This study provides a broad overview of the standardization process for a Cooperative Program (COP) through a case study in an industrial engineering (IE) department at a public university in Saudi Arabia. This study aims to investigate a systematic and consistent approach for developing, implementing, and measuring outcomes of COP policy and procedures. To this end, this study presents the process used to develop a Cooperative Program Handbook (COPH) using a standardization process model. The developed COPH includes all of the requirements, standardized process flows, expected deliverables, assessment of COP learning outcomes, mapping with ABET Student Outcomes (SOs), and continuous improvements for the COP experience. The COPH was implemented for two consecutive academic years, 2019 and 2020, in the industrial engineering undergraduate program of a public university in Saudi Arabia, in order to measure students' attainment of ABET SOs 3, 4, 5, and 7. As a result, the proposed model was successfully implemented and showed improvements and lessons learned relating to student attainment at each SO for the COP over the two academic years of implementation. The results show that the average achievement of SOs was 86.27% for direct assessment and 79.34% for indirect assessment. Afterwards, a questionnaire was conducted on 157 stakeholders to measure their satisfaction with the proposed approach. The results showed that the average overall weighted level of stakeholder satisfaction was 76.83%. It was observed that COP goals, stakeholders' roles and responsibilities, COP process flows and requirements, evaluation and assessment methods, and COP learning outcomes had a high impact on stakeholder satisfaction. Although the focus of this study was on an undergraduate engineering program in Saudi Arabia, the insights of measuring ABET SOs through this approach are quite generic and can be applied to other engineering schools beyond Saudi Arabia.

Keywords: Cooperative Program Handbook; Quality Assurance; Process Standardization; Continuous Improvement; Student Outcomes; Industrial Engineering Program; ABET Student Outcomes

1. Introduction

The concept of COP began to take shape in 1899, when Herman Schneider taught at Lehigh University and observed that most students worked while attending college or during vacations or had taken time off to work before returning to college to complete their studies [1]. Over time, the concept of COP has evolved within academic programs in order to improve learning outcomes in the professional academic degree programs [2]. Several studies have discussed COP from different perspectives, in order to explore the experience gained by students who had attended a COP using focus group interviews [3], study the relationship between COP students' perceptions of the learning environment and its impact for their career potential [4], assess the effectiveness of the COP education process and its benefits [5], and determine the level of COP importance in different engineering programs [6]. However, several challenges exist that affect faculty members' abilities to manage COPs [7], including supervising students and assessing COP experiences [8], a lack of a framework for learning in COPs [9], and a lack of clarity and direction in regard to COP impact on the development of competence [10]. Regarding management of the COP education process, a study illustrates the use of learning environments to improve co-op students' work experience in Canadian universities. The study used a model that evaluated the relationship between students' assessments of a learning environment and observed similarity to the work experience [11]. Another study introduced a model using cloud computing technology to manage a cooperative education process in Thailand. The model integrated the needs of students, the co-op supervisor, the co-op coordinator, and industry and used information and communication technology to manage the cooperative program's three main operations: pre-operation, operation, and post-operation [12]. Another example of technology use in management of the co-op education process was introduced by [13] who used a web-based co-op training system to improve management of the co-op education process in Saudi Arabia. The study

* Accepted 30 January 2022.

introduced an online communication system which collected all the necessary information from co-op stakeholders and allowed them to communicate and submit their documents and information through the online system.

Additionally, managing co-op in engineering programs requires special attention to co-op education learning outcomes and technical skills. Preparing students for the global engineering workforce requires combining technical and non-technical skills. A study at the University of Mount Union presents an approach for managing the co-op process through an international engineering field experience. The study shows how this approach increases student engagement and results in better attainment of the program-wide learning outcomes compared to other methods [14]. Another study at the University of Victoria presents the impact of combining two surveys (university and employer) to assess student attributes in a co-op program. It illustrates the different evaluation points of view between employers and university co-op administrators regarding attributes such as knowledge, lifelong learning, ethics, and project management. The results show that attention is needed in combining results from different assessment tools [15].

Obtaining academic accreditation for engineering programs from a respected body such as the ABET prepares students for the global engineering workforce and leads to better content and delivery of these programs. Several studies have discussed managing or evaluating co-op education within the context of ABET SOs (a-k) in order to [16] illustrate the need for monitoring of students during cooperative education work assignments in order to follow student adjustment and demonstrate linkages to important ABET learning outcomes; provide an assessment and evaluation strategy that involves direct and direct assessment methods for ABET SOs of computer science and computer information systems programs [17]; explore the benefit of a hybrid program that combines a traditional classroom with COPs in engineering programs at Kettering University [18], and analyze the impact of COPs on the performance of students and the achievement of student learning outcomes in engineering programs [19]. Unlike these studies, the purpose of this study is to present practical experience related to the development of a cooperative handbook (COPH), while utilizing updated ABET student outcomes (1–7) for an industrial engineering (IE) department at a public university in Saudi Arabia.

The COPH contains all of the requirements, procedures, deliverables, measurable outcomes, assessment tools, and continuous improvement plans that make up the COP. The COP example used in this study spans 26 weeks and helps students gain practical industrial engineering experience by working at an organization or a company. Every student enrolled in the IE program can choose the option of participating or not participating in the COP. Those students who chose the COP work an industry partner for 26 weeks and gain six credit hours assigned as program electives. Students must apply their knowledge about the field of IE in real-life work experiences and document their experiences for the assessment and completion of the COP.

This study illustrates the implementation of a model successfully used by previous studies for the standardization capstone design project courses in the IE program [20]. The model consists of four phases: stakeholder identification, requirement identification, assessment plan development, and continuous improvement plan development. This study adopts the model for developing the COPH in order to standardize the processes and procedures necessary for the implementation, assessment, and continuous improvement of the COP. Finally, the results of the implementation are illustrated in the results and discussion section.

2. Model Implementation

The implementation of this study took place within an IE undergraduate program in the College of Engineering at a public university in Saudi Arabia. The university has over 76,000 students out of which 2,000 are enrolled in the College of Engineering. The College of Engineering has around 100 faculty member and consists of five departments. The IE undergraduate program was used as a case for this study as it has an average of 30 COPs per year (20 in 2019; 35 in 2020). The following sections expand upon the development of the COPH based on the standardized process model, which contains four phases: identify the COP Stakeholders, identify the program requirements, develop an assessment plan, and develop a continuous improvement plan.

2.1 Identify COP Stakeholders

This phase aims to identify and determine the roles and responsibilities of all of the COP stakeholders. The identified stakeholders consist of department council, COP committee, COP supervisor, and students. Fig. 1 illustrates the relationship among the stakeholders and a description of each stakeholder is provided below.

2.1.1 Industrial Engineering Department Council

The IE department council is chaired by the department chairman and the members are all department faculty members. The council meets at least once a

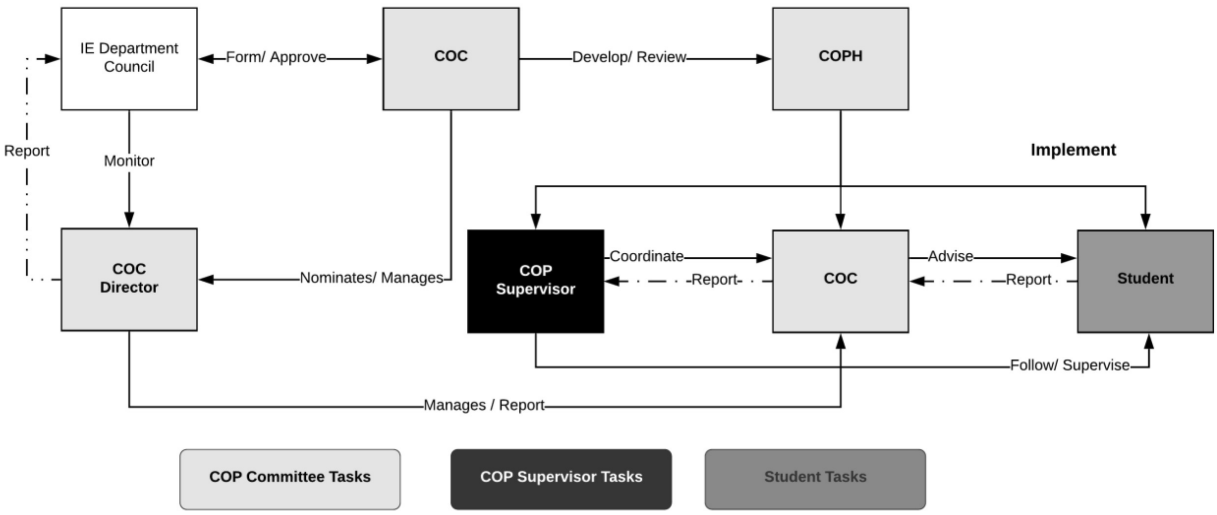

Fig. 1. Stakeholder Communication Framework.

month, at the call of the chairperson, to discuss program regulations and operations, form committees, and discuss academic and non-academic subjects. In this case study, the department council formed the COP committee (COC), which was responsible for the development of the COPH. The COPH contains policies and procedures for the COP as well as report results and findings. Any necessary changes to the COPH must be approved by the department council. In most cases, the size of COC or any other committee is between one third and half of the total number of department faculty members.

2.1.2 COP Committee (COC)

The COP Committee (COC) was formed by the IE Department council to manage the COPs. The COC was tasked with developing the COPH, which includes information on the COP requirements, stakeholders' roles and responsibilities, process flow, deliverables, and milestones. It also contains information on how to properly advise students, create an assessment plan, create a continuous improvement plan, review and assess COP practices, and report results and any needed modifications for the COPH to the department council. Each student is assigned a COC member (COPA) who advises the student, monitors the student's progress toward his/her completion of the COP, assesses the student's report and presentation after the completion of the COP, and coordinates communication with the organization or company where the COP is being undertaken. The COC represent one-third of the IE department's faculty from different tracks with practical experience; one member of the COC is nominated as the chair of the COC and must be approved by the majority of the COC members.

The major responsibilities of the COC chair are to: (1) supervise COC members, (2) prepare a list of and assign eligible students to available COP opportunities; (3) ensure that COPs are executed in a standardized fashion as shown in the process model; (4) setup and execute the COP calendar and deliverables timeline; (5) act as the liaison between the department and college administration; (6) conduct awareness seminars for the students and faculty members; (7) communicate the course policies, procedures, calendar, and assessment methods to the students; (8) confirm that the selected COPs are feasible within the specified timeframes; (9) assist the COP advisors (COPA) to refine the COP outcomes as needed; (10) ensure that the assessment criteria and evaluation forms are met and completed for all of the teams as per the COPH; and (11) develop the yearly COP binder that combines the findings and results of all of the COPs.

Other COC members played major roles in developing the COPH by identifying the COP requirements and stakeholders' responsibilities, drawing process flow figures, identifying the deliverables and milestones, advising the student, developing the assessment plans, undertaking the assessments, and developing and participating in the implementing continuous improvement plan. The COPA is assigned by the COC chair and is responsible to: (1) act as a contact point between the COP supervisor at the organization/company where the COP is being undertaken and the IE department, (2) ensure that the COP fulfills the COP polices and core competencies, (3) verify that the selected COP opportunity is feasible within the timeframe allotted, (4) identify and provide any help required for the student to have a good practical COP experience, (5) provide guidance to the student regarding IE codes and standards, (6)

ensure that the COP report submitted by the student is his/her original work, (7) attend the COP presentation rehearsal and provide guidance and feedback, and (8) assess the student's deliverables.

2.1.3 COP Supervisor

The COP supervisor is selected by the organization/company where the COP will be conducted. He/she is the contact point for the COPA in regard to supervising, monitoring, and evaluating the student at the organization/company during the COP. The COP supervisor plays a major role in the assessment plan by assessing the student's performance upon completing the COP and providing feedback from the industry related to improving the COP experience.

2.1.4 COP Student

The COP student responsible for: (1) reviewing and following the COPH timelines, milestones, and deliverables; (2) following the policies and standards of the organization hosting the COP; (3) keeping the COPA informed in a timely fashion of the COP progress and any roadblocks; (4) being responsive to the COPA and capstone coordinator regarding their communication and requests; (5) preparing the required materials for the project presentations; (6) delivering the reports and presentations on time; and (7) providing feedback related to the COP experience after completing all of the requirements.

2.2 Identification of Program Requirements for the COP

In this phase of the model, the COP requirements and process flow were identified. The requirements were identified based on two resources: the ABET requirements and IE curriculum. The ABET is considered to be the reference point for educational quality and program requirements for student outcomes [21] and has identified seven Student Outcomes (SOs) that need to be achieved during any engineering program [22]. These outcomes are broad and can fit within a variety of engineering courses and engineering disciplines; however, the broadness of the outcomes make it difficult for them to be measured directly in a COP. Thus, COC established COP goals to describe the knowledge and skills students would be required to develop during the COP. Then, to assess the level of achievements for those COP goals within the context of ABET SOs, COC developed COP learning outcomes. The COP learning outcomes align with the ABET SOs and translate the COP's goals into measurable actions produced by the students. In this study four out of the seven ABET SOs (3, 4, 5, and 7) were selected by the COC as compatible with the COP's goals. These selected ABET SOs cover the set of COP goals achieved through the COP learning outcomes. Table 1 maps out the COP goals, COP learning outcomes, and ABET SOs. Furthermore, the university's IE curriculum requires that a student must have successfully completed at least 120 of a program's 166 credit

Table 1. Mapping COP Goals with ABET Student and COP Learning Outcomes

COP Goals	ABET Student Outcomes	COP Learning Outcomes
-Expose the students to the organizational structure in typical industrial/commercial /professional institutions -Teach the students about the engineer's responsibilities in the organization in the different departments -Provide an opportunity to perform practical industrial engineering tasks according to organizational standards and the professional code of conduct	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (ABET 4)	1-1-Describe the roles and responsibilities assumed as an engineering student within the context of the organizational structure of the training institution 1-2-Adhere to professional engineering standards, institutional codes of conduct, and safety and ethics responsibilities 1-3-Conduct/perform the engineering tasks assigned by a supervisor in a professional manner and as described by the company/institution's policies and procedures
-Expose students to practical team working environments and provide information on the different roles in professional industrial engineering environments	An ability to function effectively in a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (ABET 5)	2-1-Participate effectively in teams to perform the assigned tasks, while respecting other contributions and following the organization's code of conduct
-Learn how to develop and implement self-learning plans in the relevant industrial engineering field	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies (ABET 7)	3-1-Follow appropriate strategies to learn/apply new techniques related to assigned tasks
-Train the students on different forms of practical technical communications and enhance their ability to communicate with people who have different technical backgrounds	An ability to communicate effectively with a range of audiences (ABET 3)	4-1-Communicate effectively using different forms of written and oral technical communications with people who have different technical backgrounds

hours, including five junior level courses, to be eligible for enrollment in the COP.

2.3 COP Assessment

This phase of the model focused on developing an assessment plan that would allow the department to implement consistent assessments across COPs. The assessment plans were developed by the COC and included all of the stakeholders so as to gain complete feedback. This feedback was essential to phase four of the model. The first elements of the assessment plan are a report and a presentation, which need to be submitted by each student after he or she completes the COP. The report and presentation, which account for 40% and 20% of the total COP mark respectively, need to be professionally prepared and are assessed by the COPA and two COC members assigned by the COP chair. The COP report contains: (1.) an introduction of the organization or company where the COP was held, including its structure and standards; (2.) a description of the roles and responsibilities assigned to the student during the COP; (3.) an explanation of how IE knowledge and skills were applied during the COP; (4.) an example of teamwork that the student participated in during the COP, and (5.) a conclusion and summary of the main findings from the COP. The second element of the assessment plan, which accounts for 40% of the total COP mark, occurs when the COP supervisor provides an evaluation (direct assessment) of the student's performance and offers recommendations for improvements to the overall COP process and procedures. The final element of the assessment plan occurs when the student conducts an indirect assessment of his or her attainment of the SOs. This assessment allows the department to determine how well the students attain the SOs through this program as well as determine areas of improvement for the program and processes. The COC developed the assessment plan's rubrics based on the COP learning outcomes and forms to assess the student's performance and evaluate the COP experience. More details about each form are provided below.

- **The COP report direct assessment form (see Appendix 1).** The evaluation criteria for the COP report assess the student's (1.) description of the roles and responsibilities that he or she was assigned during the COP within the context of the organizational structure of the training institution; (2.) demonstration of teamwork during the COP; (3.) demonstration of his or her ability to apply and learn knowledge in industrial engineering, and (4.) effectiveness in communication (communication in a manner that can be understood by individuals from diverse technical backgrounds). Each criterion is aligned with one of the ABET SOs (3, 4, 5, and 7) and each accounts for 10% of the total COP mark. COPA and two COC members used the analytic rubric to evaluate each criterion on a scale from 1–4 where 1 is poor and 4 is excellent. Then, the received score for each criterion was converted to 10% (for example, if a received score in one of the criteria is 3.5 out of 4, the weighted grade for that criterion will be equal to 8.75 out of 10.)
- **The COP presentation direct assessment form (see Appendix 2).** The evaluation criteria for the COP presentation are based on (1.) the overall organization of the presentation (e.g., slide flow, content, time frame); (2.) the student's technical competency (e.g., details about the organization or company, description of the roles and assigned tasks, problem analysis, and implementation of industrial engineering knowledge); (3.) the student's preparation and appearance (e.g., facing the audience to present, level of dress), (4.) the student's communication skills, and (5.) the student's ability to answer questions. Because the oral presentation assessment worked mainly to measure student communication skills, all five criterions are aligned with ABET's third student outcome. COPA and two COC members used the analytic rubric to evaluate each criterion on a scale from 1–4, where 1 is poor and 4 is excellent. In the presentation assessment, the score assigned for each criterion was the same weighted mark of 4% from the COP total mark, discussed above.
- **The COP supervisor evaluation form (see Appendix 3).** The evaluation criteria for this form are based on a direct assessment of a student's (1.) responsibility as an engineer within the organization's code of conduct, (2.) quality of work, (3.) performance on his or her assigned tasks, (4.) adherence to safety and ethics, (5.) adherence to professional engineering standards, (6.) ability to apply critical thinking in solving problems, (7.) ability to meet deadlines for assigned tasks, (8.) effective participation in a team while respecting others' contributions, (9.) ability to follow appropriate instructions related to assigned tasks, (10.) ability to learn new techniques related to assigned tasks and the IE field, (11.) ability to apply an engineering background in solving assigned tasks, (12.) ability to communicate effectively using different forms of written technical communication, and (13.) performance of oral communication with individuals. Each of these criteria has a descriptive statement aligned with one of the ABET SOs, wherein criterions 1–5 aligned with ABET SO 4, criterions 6–9 aligned with ABET SO 5, criterions 10 and 11 aligned

with ABET SO 7, criterions and 12 and 13 aligned with ABET SO 3. The COP supervisor evaluated each criterion on a scale from 1–5 where 1 is poor and 5 is excellent. Then, the total score of every criterion group was used to calculate the weighted mark out of 10%. For example, if the total received mark in criteria 6–9 (which aligned with ABET SO 5) is 17 out of 20, then the weighted mark for ABET SO 5 is 8.5 out of 10. In addition, the COP supervisor provides a recommendation for improvements for the COP, which helps the COC to review COP process.

- **Student indirect assessment form (see Appendix 4).** This assessment is done by the student and aims to evaluate his or her achievement in the following areas: (1.) responsibility as an engineer within the organization's code of conduct, (2.) quality of work, (3.) performance on his or her assigned tasks, (4.) adherence to safety and ethics, (5.) adherence to professional engineering standards, (6.) ability to apply critical thinking in solving problems, (7.) ability to meet deadlines for assigned tasks, (8.) participation in a team while respecting others' contributions, (9.) following appropriate instructions related to assigned tasks, (10.) ability to learn new techniques related to assigned tasks and the IE field, (11.) ability to apply engineering background in solving assigned tasks, (12.) ability to communicate effectively using different forms of written technical communications, and (13.) performance in oral communication with individuals. Each of these criteria has a descriptive statement aligned with one of the ABET SOs, wherein criterions 1–5 aligned with ABET SO 4, criterions 6–9 aligned with ABET SO 5, criterions 10 and 11 aligned with ABET SO 7, and criterions 12 and 13 aligned with ABET SO 3. Each student evaluates himself or herself after COP completion against each criterion on a scale from 1–5 where 1 is poor and 5 is excellent. Then, the total score of every criterion group is used to calculate the weighted mark out of 25%. For example, if the total received mark in criterion 6–9 (which aligns with ABET SO 3) is 6 out of 10, then the weighted mark for ABET SO 3 is 15 out of 20. In addition, students provide feedback about the organization or company where the COP was held based on: (a) level of knowledge and practice gained from the COP, (b) to what extent a well-planned schedule and assigned tasks were provided, (c) how well the organization provided information about the organization's code of conduct and health and safety procedures, (d) how well the COP supervisor provided guidance and support, (e) how well the IE department's administration provided orientation prior to the start of the COP, (f) how well the COPA provided support during the COP. Lastly, the student is given an opportunity to provide his or her recommendations for improving the COP.
- **The COP final grade form (see Appendix 5).** This form is completed by the COPA after the above assessments are completed, in order to summarize the marks for each student on each direct assessment element. This helps the COC to map each assessment element in regard to its alignment with the COP learning outcomes and ABET SOs. The total COP mark table in this appendix illustrates the student's total mark for the COP and his or her total attainment on each ABET SO. In addition, it shows the calculation of the total COP mark out of 100 and how it is derived from each assessment element (the COP report assessment form and the COP presentation assessment form.)

2.4 Continuous Improvement

The last phase of the model is aimed at continual improvement of the COP experience for all stakeholders. This phase provides a systematic and continuous approach toward improving and managing COP processes and procedures. The continuous improvement plan takes place after the previous section is completed and implemented. The COP chair develops an annual COP report that illustrates the attainment results related to the SOs based on the direct and indirect assessments. Additionally, the report discusses assessment results and feedback received from all of the stakeholders. Finally, the report is used to prompt discussion about recommendations for improvement to the COPH by the department council.

2.5 COP Process Flow

This section illustrates the implementation of the COP process based on the COPH from start to finish within the academic year's weekly timeline. Every student interested in applying for the COP in the IE program must follow the COP process flow as illustrated in Fig. 2. First, a formal written request for a COP opportunity should be submitted by the student to the COP chair between weeks 13–14 of the semester, prior to the semester when the student wants to participate in the COP. Approval or denial of the request usually takes one week, as the administration must determine whether the student is eligible to register for the COP. A student who is eligible for the COP will be assigned a COPA during their COP enrollment. Once the student is approved for the program, it may take up to four weeks for a COP opportunity to be assigned to the student by the COP chair. COP opportunities may come from a variety of sources including local

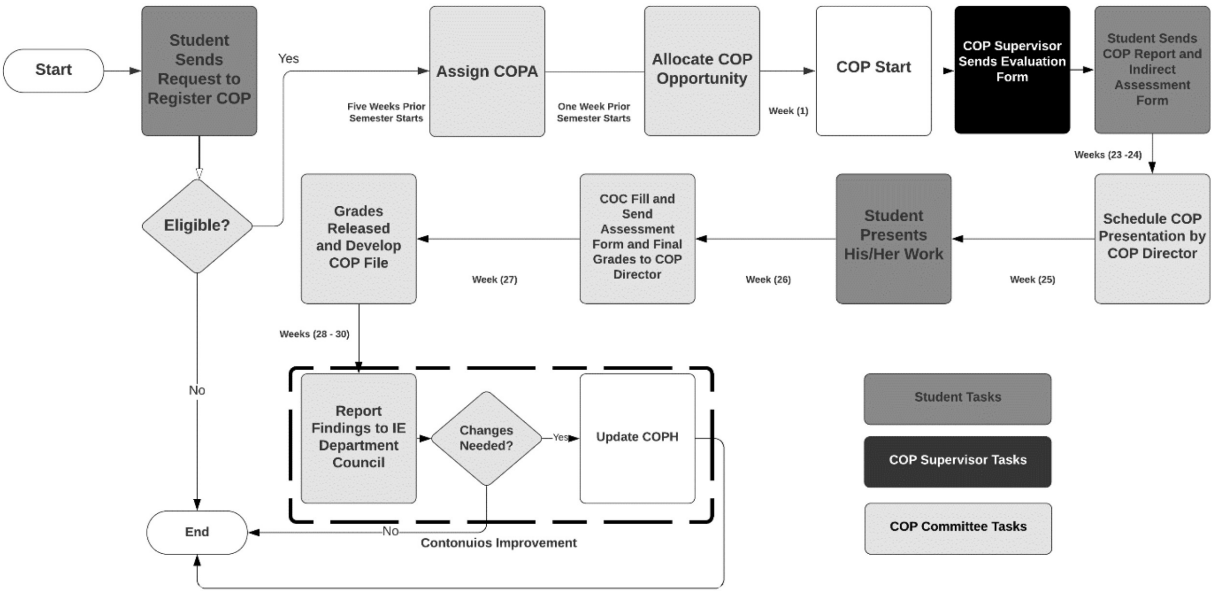

Fig. 2. COP Process Flow.

industry, international organizations (e.g., the International Association for the Exchange of Students for Technical Experience) [23], and research and outreach conducted by the student and approved by the local or international organization/company.

The COP begins during week 1 of the following semester, after the previous steps are completed. By this time, both the COPA from the IE department and the COP supervisor at the organization or company have been introduced so as to monitor the progress of the student in the COP. After the completion of the COP (by weeks 23–24) students are required to submit their reports, presentations, and student evaluation forms to their COPA. In addition, the COP supervisor must fill out the supervisor evaluation form and give it to the COPA. Next, the presentation schedule will be developed by the COC chair for all of the COP students by week 25 and the presentations will be conducted in week 26. By the end of week 26, the COPA will have collected the report and presentation assessment forms from the COC members, the supervisor evaluation form, and the student's indirect assessment form. The COPA will use the findings from the assessment and evaluation forms to complete the final grade assessment form and will send the results to the COP chair so that he or she can add the final grades to the university system by week 27. All assessment and evaluation results, as well as feedback from the stakeholders, will be gathered by the COP chair between weeks 28–30 so that he or she can write the annual report. Once the report is complete and has been disseminated, the IE department council will discuss the findings and any proposed changes to the COPH. This cycle takes place yearly to maintain continuous improvement.

3. Results and Discussion

The development of the COPH will help all stakeholders fully comprehend the COP. Such a document will positively impact the education quality by measuring student outcomes, which will consequently ensure continuous improvement of the COP experience to achieve remarkable results. As a result of implementation of the developed COPH, the ABET SOs 3–5 and 7 were measured using direct and indirect assessments and results reported (practical evidence of the effectiveness of the COPH) and were able to show areas of further improvement for the COPH. Table 2 shows the results of the direct and indirect assessments for the attainment of the SOs for 2019 and 2020. The results showed a systematic approach for measuring the COP in alignment with the SOs. Next, the results of assessment for all SOs are discussed in more detail.

3.1 Assessment Results for ABET Student Outcome 4

Fig. 3 shows the direct and indirect assessment results for ABET SO 4 in the years 2019 and 2020. It illustrates the average percentage of student attainment from the results of each evaluation criterion of the assessment elements where R is the report's COP direct assessment form, and Q1 to 5 are evaluation criterions 1 to 5 in both COP supervisor evaluation form and student indirect

Table 2. COP Attainment using Direct and Indirect Assessments for 2019 and 2020

Student Outcome	COP Learning Outcome	Assessment Type	2019 Attainment Percentage	2020 Attainment Percentage
(ABET 4)	1-1 1-2 1-3	Direct	79.2%	87.7%
		Indirect	77.29%	88.85%
(ABET 5)	2-1	Direct	86.37%	94.16%
		Indirect	76%	74.13%
(ABET 7)	3-1	Direct	91.40%	93.89%
		Indirect	74%	80.10%
(ABET 3)	4-1	Direct	78.98%	78.46%
		Indirect	80%	84.32%

assessment form. Although the overall results in 2019 and 2020 for student attainment on direct and indirect assessment are above the acceptable threshold of 70%, the direct assessment results of Q4 (which refers to adherence of students to professional engineering standards) performed at low level of student attainment (63.73%) in 2019. This was due to lack of availability of engineering standards specified to the field of industrial engineering. Thus, COC decided to introduce general information about engineering standards prior to COP registration time and provide some examples from local and international organizations such as the Saudi Council of Engineers (SCE) and the Occupational Safety and Health Administration (OSHA). This practice had a positive impact on student awareness of engineering standards and consequently improved average student attainment by approximately 17% the following year.

3.2 Assessment Results for ABET Student Outcome 5

The direct and indirect assessment results for ABET SO 5 in the years 2019 and 2020 are illustrated in Figs. 4 and 5. The average student attainment percentage is collected from the results of each evaluation criterion of the assessment elements, where R is the report's COP direct assessment form, and Q6 to 9 are evaluation criterions 6 to 9 in both the COP supervisor evaluation form and the student indirect assessment form. ABET SO 5 is related to the ability of students to function effec-

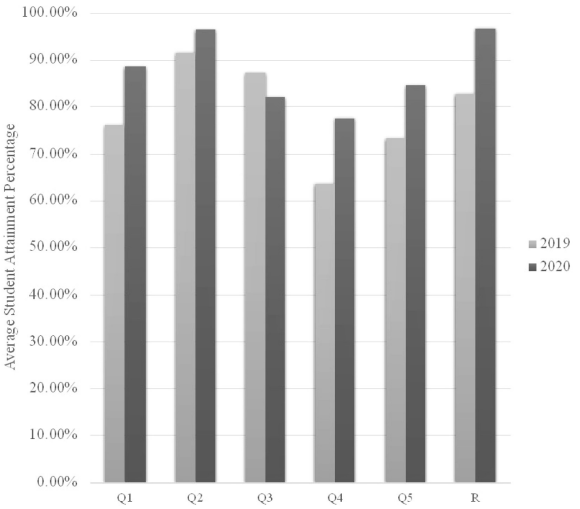

Fig. 3. Direct Assessment Results for ABET SO 4.

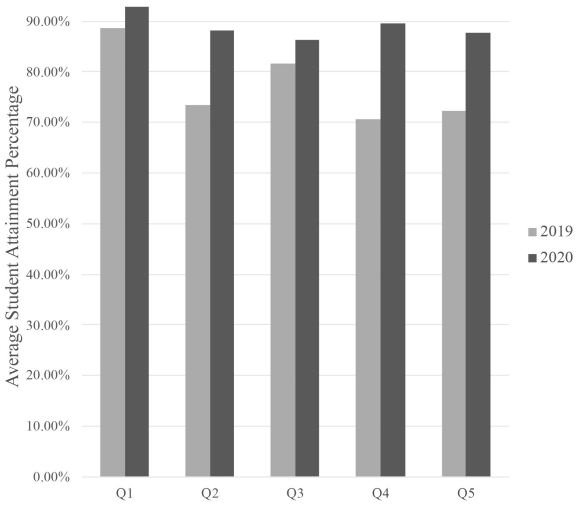

Fig. 4. Indirect Assessment Results for ABET SO 4.

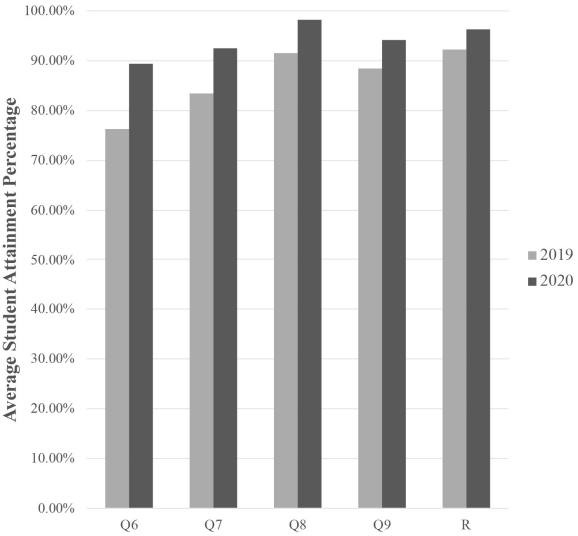

Fig. 5. Direct and Indirect Assessment Results for ABET SO 5.

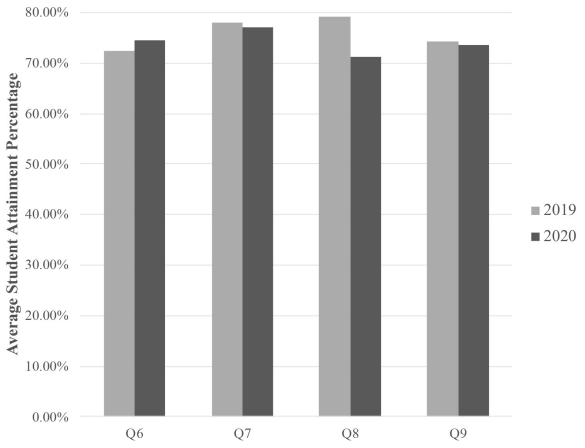

Fig. 6. Indirect and Indirect Assessment Results for ABET SO 5.

tively in teamwork. The overall average percentage of student attainment expressed above 70% in all criterions for both direct and indirect assessments. This is a result of the IE program requirements for COP, which require students to have successfully completed at least 120 of the program's 166 credit hours, including five junior level courses, to be eligible for enrollment in the COP. This requirement exposes student to teamwork environments and encourages collaboration with other team members at the junior level courses prior to enrolment in the COP.

3.3 Assessment Results for ABET Student Outcome 7

The results of direct and indirect assessment for ABET SO 7 (which covers the ability of students to acquire and apply new knowledge) are shown in Figs. 6 and 7. The average student attainment percentage is collected from the results of each evaluation criterion of the assessment elements, where R is the report's COP direct assessment form, Q10 (DA) and Q11 (DA) are the evaluation criterions 10 and 11 in the COP supervisor evaluation form, and Q10 (IA) and Q11 (IA) are the evaluation criterions 10 and 11 in the student indirect assessment form. Although the overall results in 2019 and 2020 for student attainment on direct and indirect assessment are above the acceptable threshold of 70%, the indirect assessment results of Q10 raised concern when they fell at the borderline of the threshold (70.35%) in 2020. The COC investigated the assessment results of Q10, which refers to the ability of students to learn new techniques and practices related to the industrial engineering field. The result of this investigation led to determination of a cause, which was a lack of sufficient site visit restrictions put in place as precautionary measures to confront the COVID-19 pandemic. Furthermore, students were not able to access international COP opportunities, which led to lack of available COP opportunities that time compared to the previous year. Therefore, the assessment results of Q10 were considered as a special event in the assessment process and are expected to be resolved when precautionary COVID-19 measures are reduced in the coming years. Also, a recommendation was made to organizations to provide online or hybrid COP modules if the restrictions to site visits are to continue.

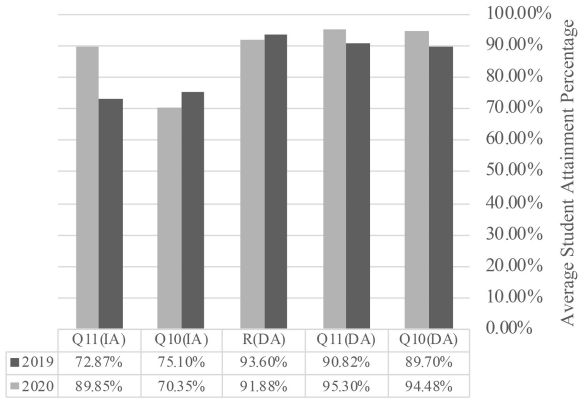

Fig. 7. Direct and Indirect Assessment Results for ABET SO 7.

3.4 Assessment Results for ABET Student Outcome 3

Fig. 8 shows the direct and indirect assessment results for ABET SO 3, which is related to ability of students to communicate effectively with a range of audiences. The average percentage of student attainment for this SO is collected from the results of each evaluation criterion of the assessment elements, where R is the report's COP direct assessment form, P is the presentation's COP direct assessment form, Q12 (DA) and Q13 (DA) are the evaluation criterions 12 and 13 in the COP supervisor evaluation form, and Q12 (IA) and Q13 (IA) are the evaluation criterions 12 and 13 in the student indirect assessment form. The overall results in

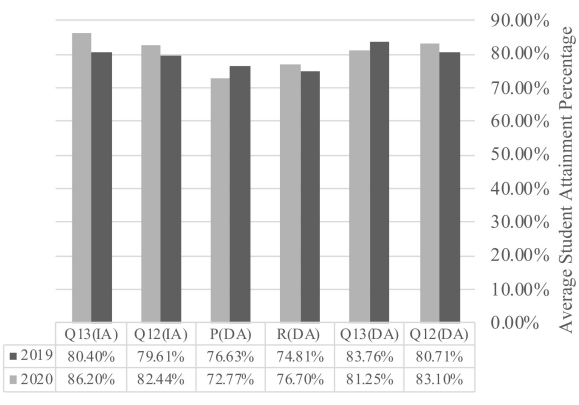

Fig. 8. Direct and Indirect Assessment Results for ABET SO 3.

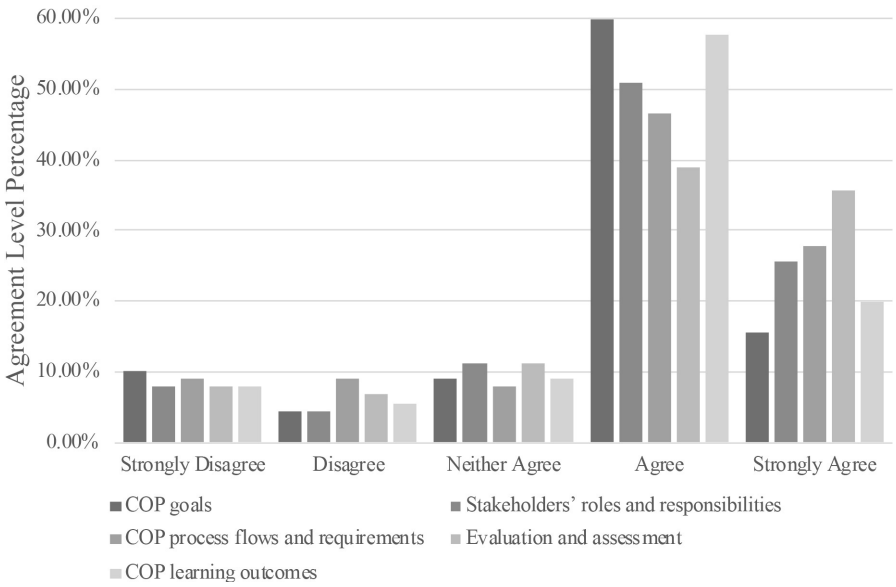

Fig. 9. Agreement Level for the COPH.

2019 and 2020 for both direct and indirect assessment were determined to be at an average level of 78.72% for direct assessment and 82.16% for indirect assessment. In addition, it can be seen in presentation assessment results from the year 2020 that further improvement in COP presentation guidelines is needed to maintain consistency in student deliverables and improvement in assessment results.

After implementing the COPH for two consecutive years, the COC measured the usefulness of the COPH from the stakeholders' perspectives. A survey instrument was developed based on a binary scale of 1–5, where 1 was strongly disagree, and 5 was strongly agree. Fig. 9 shows the responses' percentages in the five evaluation clusters. The evaluation criterions used to measure the usefulness of the COPH, starting from the left in every cluster, are COP goals, stakeholders' roles and responsibilities, COP flow and requirements, evaluation criteria, and COP learning outcomes. A total of 187 responses were collected from stakeholders. Of these responses, 157 were complete and usable. For each criterion in the survey, participants were asked about their level of agreement as to whether the COPH was clearly stated, well-defined, and unambiguous. The overall responses reported an average satisfaction level of 76.83%.

Combining the responses of agree and strongly agree, the agreement level with the COP learning outcomes criterion was found to be the highest at 77.80% and evaluation criterion the lowest at 74.50%. Several participants believe that measuring COP learning outcomes designed by the COC is easier for evaluation of students' performance on the COP. The COP helps in translating the broad statements of ABET SOs into action measures of COP experience. However, participants believe that the evaluation process requires several forms and that final student scores need to be calculated manually from these forms, thus creating a need for a web-based platform where all evaluation forms are electronically filled and final scores are automatically calculated. This will be considered for future improvement. If this is done, the evaluation process will not only be easier for educators, supervisors, and learners but also help create a useful database for analyzing COP education.

4. Conclusion

The focus of this study was the use of a standardization process model to standardize and improve the COP's processes and procedures for continuous improvement purposes. The standardization process model was used to ensure systematic monitoring of student attainment levels and project deliverables as well as provide a continuous improvement cycle to improve the COP experience. The study showed that a systematic process flow existed from the student's COP registration through evaluation, monitoring, and continuous improvement across all COP stakeholders. As a result, the proposed model was successfully implemented and showed an improvement in student attainment for the COP over the two academic years of implementation. The average achievement on direct SO assessment across the COP for the two studied years was 86.27%, while the average achievement on indirect SO assessment was

79.34%. This study shows that lack of availability for industrial engineering standards affects student attainment on ABET student outcome 4 (student adherence to professional engineering standards). Consequently, introducing students to general information about engineering standards from local and international organizations such as SCE and OSHA helps in improving student attainment. Similarly, entering the COP after the junior level of the academic program helps in improving student attainment on ABET student outcome 5 (the ability of students to function effectively in teamwork) during the COP.

After implementing the COPH for two academic years, it was important to measure stakeholder satisfaction; therefore, a questionnaire was conducted to measure the usefulness of the COPH from the stakeholders' perspectives. The results showed that the average overall weighted level of stakeholder satisfaction was 76.83%. Although the COP learning outcomes received the highest stakeholder agreement level due to the simplicity of measuring ABET SOs, a web-based platform was recommended to simplify the evaluation process for educators, COP supervisors, and students and create a useful database for analyzing COP education. Finally, obtaining ABET accreditation for an engineering program is a generic process for any school. The process requires a systematic procedure for student outcome assessment and continuous data-driven improvement. Thus, the purposed approach from this study is quite generic and can be applied to other engineering schools beyond Saudi Arabia. Future studies could utilize the results of this study at different universities and in other engineering programs to compare their practices in managing COPs. In addition, more experimental analysis could be done to investigate the factors within the COP that had the most impact on improving overall attainment of the SOs.

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Appendices

Appendix 1: COP Report Assessment Form

COP Report Assessment Form

Student Name	
Student ID	
Organization/Company Information	
Grader Name	
COPA	
Date	

Please grade the COP report based on the criteria and rubric below:

Program Outcome	Criteria	Achievement	Mark	Score
(ABET 4)	☐ Excellent introduction about the organization/company and COP ☐ Clearly describes his/her roles and responsibilities during the COP ☐ Clearly explains the implementation of engineering standards ☐ Excellent demonstration of assigned tasks and clearly explained how they were handled	Excellent (Exceeds Expectations)	4	/4
	☐ Acceptable introduction about the organization/company and COP ☐ Fair description of his/her roles and responsibilities during the COP ☐ Acceptable illustration related to the implementation of engineering standards ☐ Acceptable demonstration of assigned tasks and some information about how they were handled	Very Good (Meet Expectations)	3	
	☐ Lack of information about the organization/company and COP ☐ Missing information about his/her roles and responsibilities during the COP ☐ Lack of illustration related to the implementation of engineering standards ☐ Does not adequately demonstrate assigned tasks and has a lack of information about how they were handled	Good (Barely Meets Expectations)	2	
	☐ Poor introduction about the organization/company and COP ☐ Inappropriate description and information of his/her roles and responsibilities during the COP ☐ Poor illustration related to the implementation of engineering standards ☐ Inappropriate demonstration of assigned tasks and poor information about how they were handled	Poor (Fails to Meet Expectations)	1	

Program Outcome	Criteria	Achievement	Mark	Score
(ABET 5)	☐ Excellent illustration of teamwork examples	Excellent (Exceeds Expectations)	4	/4
	☐ Acceptable illustration of teamwork examples	Very Good (Meet Expectations)	3	
	☐ Lack of illustration of teamwork examples	Good (Barely Meets Expectations)	2	
	☐ Inappropriate or missing illustration of teamwork examples	Poor (Fails to Meet Expectations)	1	

Program Outcome	Criteria	Achievement	Mark	Score
(ABET 7)	☐ Clearly explains techniques and methods used to perform assigned tasks	Excellent (Exceeds Expectations)	4	/4
	☐ Acceptable explanation of techniques and methods used to perform assigned tasks	Very Good (Meet Expectations)	3	
	☐ Incomplete explanation of techniques and methods used to perform assigned tasks	Good (Barely Meets Expectations)	2	
	☐ Poor and irrelevant explanation of techniques and methods used to perform assigned tasks	Poor (Fails to Meet Expectations)	1	

Program Outcome	Criteria	Achievement	Mark	Score
(ABET 3)	☐ Coherent and well-written **content;** detailed, in-depth **analysis**; **practical** implementation; well-explained ☐ Excellent **formatting**, strong demonstration of tables and figures ☐ Uses excellent **words and language within the related industry and field**, no grammar mistakes, and has an excellent writing flow	Excellent (Exceeds Expectations)	4	/4
	☐ Acceptable written **content,** but lack of some details, analysis, and practical implementation explanations ☐ Acceptable **formatting** and acceptable demonstration of tables and figures ☐ Uses acceptable **words**, has some grammar mistakes, and has an acceptable flow in the writing	Very Good (Meet Expectations)	3	
	☐ Lack of written **content**; details, analysis, and practical implementation are not appropriate ☐ **Formatting**, tables, and figures need major changes ☐ Uses inappropriate **words and language within the related industry and field**, makes some grammar mistakes, and has a lack of flow in the writing	Good (Barely Meets Expectations)	2	
	☐ Poor written **content**; details, analysis, and practical implementation need major changes ☐ **Formatting**, tables, and figures are poorly done ☐ Uses irrelevant **words and language within the related industry and field**, has major grammar mistakes, and has an inappropriate writing flow	Poor (Fails to Meet Expectations)	1	

Appendix 2: COP Presentation Assessment Form

COP Presentation Assessment Form

Student Name	
Student ID	
Company/Organization	
Grader Name	
COPA	
Date	

This form is to be used to measure student outcomes (ABET 3). Please grade the student based on the criteria and rubric below:

Criteria	1	2	3	4	Student Score Out of 4
Overall Organization	☐ The **slides** were disorganized, unrelated to the topic, and missing appropriate visual content (e.g., background, colors, font size, figures).	☐ The content of some of the slide was irrelevant and/or badly prepared. A lack of appropriate visual content occurred (e.g., background, colors, font size, figures).	☐ Acceptable and logical content for the **slides**. Acceptable visual content (e.g., background, colors, font size, figures)	☐ Coherent and well-presented content for the slides. Excellent visual content (e.g., background, colors, font size, figures)	/4
Technical Competency	☐ No appropriate **design** and are no **analysis** or **solution approach**	☐ **Design**, **analysis**, and **solution approach** requires major improvements	☐ A lack of details existed in the **design and analysis,** but the **solution approach** was acceptably explained.	☐ Excellent **design**, well-detailed, in-depth **analysis**, and the **solution** was well explained	/4
Preparation and Appearance	☐ Completely **unprepared**, unacceptable **dress**, and presented by **reading notes**	☐ Insufficient **rehearsal** and practice, inappropriate **dress**, and occasionally **read directly from the slides**	☐ Good prior **practice**, appropriately **dressed**, and no distracting **pauses and gestures**	☐ Well-**prepared**, professionally **dressed**, and well-focused and **facing audience** the entire the time	/4
Communication Skills	☐ Used irrelevant **words**, many mistakes in **grammar**, and a lot of difficulties **speaking**	☐ Used inappropriate **words,** some **grammar** mistakes, and some difficulties **speaking**	☐ Used acceptable **words**, had few mistakes in **grammar**, and had a good speaking flow	☐ Used excellent **words**, did not have any mistakes in **grammar**, and had an excellent speaking flow	/4
Answering Questions	☐ Had no clue (i.e., got **answer** completely wrong)	☐ **Answer** and explanation inappropriate	☐ **Answer** was appropriate, but lacked focus	☐ Excellent **answer**: well-focused, creative, and appropriate	/4

Appendix 3: COP Supervisor Evaluation Form

COP Supervisor Evaluation From

Supervisor Name	
Supervisor Contact Information	
Date	

Student ID	**Student Name**

Please evaluate the student's performance upon his/her completion of the COP where 1 = the lowest level of skill and 5 = highest level of skill. The student was able to:

Evaluation Criteria	Score	Total Score
An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (ABET 4)		
1. Conduct assigned duties and responsibilities as an engineer within the context of the organizational structure where the COP was applied	/5	/25
2. Deliver high quality work for performed tasks	/5	
3. Perform work with punctuality and independence	/5	
4. Adhere to professional engineering standards	/5	
5. Adhere to the company/organization's code of conduct	/5	
An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (ABET 5)		
6. Student has both the aptitude and skills necessary to perform the assigned tasks	/5	/20
7. Complete assigned tasks with persistence to meet deadlines	/5	
8. Participate effectively and respect others when working with teams	/5	
9. Follow appropriate instructions to learn/apply new techniques related to assigned tasks	/5	
An ability to acquire and apply new knowledge as needed, using appropriate learning strategies (ABET 7)		
10. Learn new techniques and practices related to the IE field	/5	/10
11. Apply his/her background in engineering sciences and techniques in solving the assigned tasks	/5	
An ability to communicate effectively with a range of audiences (ABET 3) 12. Effectively communicate written concepts across a variety of software applications.	/5	/10
13. Perform oral communication effectively with individuals who have diverse technical backgrounds	/5	

Other Feedback:

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Appendix 4: Student Indirect Assessment Form

COP Student Indirect Assessment From (Student Self-Evaluation)

This form needs to be filled out by student.

Student Name	
Student ID	
Organization/Company Information	
Supervisor Contact Information	
COPA	
Date	

Please evaluate your performance upon your completion of the COP where 1 = the lowest level of skill and 5 = highest level of skill.

Evaluation Criteria	Score	Total Score
An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of the engineering solutions in global, economic, environmental, and societal contexts (ABET 4)		
1. I was able to conduct my assigned duties and responsibilities as an engineer within the context of the organizational structure where the COP was applied.	/5	/25
2. I was able to deliver high quality work for my performed tasks.	/5	
3. I was able to perform my work with punctuality and independence.	/5	
4. I was able to adhere to professional engineering standards.	/5	
5. I was able to adhere to the company/organization's code of conduct.	/5	
An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (ABET 5)		
6. I had the aptitude and the necessary skills to perform the assigned tasks.	/5	/20
7. I was able to complete my assigned tasks with persistence to meet my deadlines.	/5	
8. I was able to participate effectively and respect others when working with teams.	/5	
9. I was able to follow appropriate instructions to learn/apply new techniques related to my assigned tasks.	/5	

An ability to acquire and apply new knowledge as needed, using appropriate learning strategies (ABET 7)		
10. I was able to learn new techniques and practices related to the industrial engineering field.	/5	/10
11. I was able to apply my background in engineering sciences and techniques to solve my assigned tasks.	/5	
An ability to communicate effectively with a range of audiences (ABET 3)		
12. I was able to effectively communicate written concepts across a variety of software applications.	/5	/10
13. I was able to perform oral communication effectively with individuals who had diverse technical backgrounds	/5	

Other Feedback:

_____

_____

Appendix 5: Final Grade Form

COP Final Grade Form

Student Name	
Student ID	
Company/Organization Information	
COPA	
Date	

Report From					
Student Outcome	**COC Member 1**	**COC Member 2**	**COCA**	**Average**	**Weighted Mark**
ABET 4	/4	/4	/4	/4	/10
ABET 5	/4	/4	/4	/4	/10
ABET 7	/4	/4	/4	/4	/10
ABET 3	/4	/4	/4	/4	/10

Presentation Form					
Student Outcome	**COC Member 1**	**COC Member 2**	**COCA**	**Average**	**Weighted Mark**
ABET 3	/20	/20	/20	/20	/20

COP Supervisor Evaluation Form		
Student Outcome	**Total**	**Weighted Mark**
ABET 4	/25	/10
ABET 5	/20	/10
ABET 7	/10	/10
ABET 3	/10	/10

Total COP Direct Assessment				
Student Outcome	**Report**	**Presentation**	**COP Supervisor**	**Total**
ABET 4	/10		/10	/20
ABET 5	/10		/10	/20
ABET 7	/10		/10	/20
ABET 3	/10	/20	/10	/40
Total				/100

Total COP Indirect Assessment		
Student Outcome	**Total Score**	**Weighted Mark**
ABET 4	/25	/25
ABET 5	/20	/25
ABET 7	/10	/25
ABET 3	/10	/25
Total		/100

Role	Name	Signature
COPA		
COC Member 1		
COC Member 2		
COP Director		

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