Industrial Training Courses: A Challenge during the COVID19 Pandemic

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***Abstract*—Industrial training courses require students to gain sufficient practical engineering experience that confirms theoretical knowledge by application to field work. The courses expose students to real life engineering activity involving problem solving, design, experimentation and manufacturing. Students get introduced to entrepreneurship, diverse collaborative work environments and quality systems that instill world class safety standards and professional ethics. Preventive measures and lockdowns during prolonged pandemic conditions have severely limited students' capability for in-person participation of onsite industrial training programs, thereby, adversely affecting the scope of training courses. This paper presents some plausible solutions to challenges faced by both instructors and students in fulfillment of essential outcomes for remote offerings of industrial training courses during the COVID19 pandemic. Essential aspects of an outcome based digital platform used for remote management, assessment and evaluation of industrial training courses are presented. A course template that facilitates virtual engineering roles as viable alternative to students' in-person participation in industry settings is explained. This study compares two course models offered prior to and during pandemic conditions for fulfillment of course outcomes, makes observations of required skills and knowledge, related deficiencies and some recommendations to help engineering programs enhance student learning in remotely offered industrial training courses.**

Keywords—OBE, outcomes, assessment, evaluation, ABET, industrial training

I. Introduction

Industrial training is recognized as an essential component of engineering education globally. Training courses provide crucial technical and transversal skills especially important for engineering graduates aspiring to compete in a global labor market. Over the last two decades, quality and accreditation agencies worldwide have emphasized the importance of integrating transversal competencies in engineering education curricula in order to prepare students for the engineering labor market [1,2]. Care and Luo defined transversal competencies as skills, values and attitudes required for learners' holistic development [3] and are also known in research literature as employability skills [4], professional skills [5] and twenty-first century skills [6]. Industrial exposure provides students with both the technical and transversal skills necessary for holistic development required by state of the art engineering education. According to Jesus and Urbano [7], "Industrial training activities can be defined as periods of engineering education outside the University geographical space that are oriented towards providing the students with knowledge and competences not easily obtained at class- rooms ... on the other hand, industrial refers here to any organized human group implied in producing goods or supplying services. In this sense, the term industry includes public or private manufacturing or services firms but also public administrations, co-operatives, trade unions, NGO´s, foundations and other collectives."

Several international accreditation agencies such as the Accreditation Board of Engineering Technology (ABET), International Engineering Alliance's (IEA) Washington Accord [8], EUR-ACE ® [9] and Saudi's National Commission for Academic Accreditation & Assessment (NCAAA) [10] strongly recommend that industrial training courses should be an integral part of the engineering curriculum to comprehensively cover their graduate attributes or Student Outcomes (SOs). The training programs provide students with hands on experience in practical engineering activity involving problem solving, design, experimentation, and manufacturing. Students also get introduced to entrepreneurship, diverse collaborative work environments and quality systems that instill world class safety standards and professional ethics. Since accreditation agencies base students' learning on an Outcome Based Education (OBE) model [11], all teaching, learning, assessment, evaluation, feedback and improvement efforts have to be related to outcomes information. An exhaustive study of 99 research articles [12] concluded that due to global accreditation requirements the number of published studies from 2000 to 2017 related to assessment and evaluation of transversal skills had significantly increased. They observed that in general, international quality standards for assessment and evaluation of transversal skills such as communication, innovation, creativity, lifelong learning or teamwork were undefined and deficient. Specifically, inadequate standards of language of learning outcomes, validity and reliability of assessments, and vague rubrics, all exacerbated the evaluation of transversal skills. Typical undergraduate engineering programs cover several hundred learning activities which are difficult to manage and assess using manual quality systems. These activities involve knowledge and skills corresponding to all the 3 Bloom's domains and their learning levels [13-16]. Therefore, assessment and evaluation of off campus student learning experiences dealing with real time technical and transversal skills would indeed be a complex affair [17]. Several publications have mentioned automated digital systems that facilitate learning management and outcomes assessment as possible solutions to streamlining the outcomes data collection and reporting efforts [15,16,18,19,20]. In this study, we shall present some samples of remote assessment and evaluation of student learning activity using digital web-based platform EvalTools 6 ® for summer training courses of the Electrical (EE), Mechanical (ME) and Civil (CE) engineering programs at the Islamic University (IU).

Since the end of February 2020, the Ministry of Education, Saudi Arabia has mandated stringent measures for educational institutions across the nation to observe strict social distancing norms and offer all courses remotely. Until further notice, students are barred from in-person class attendance on campus and cannot visit any industrial sites for vocational training. Engineering programs have no choice left but to consider employing digital platforms offering Learning Management (LMS) and Outcomes Assessment (OAS) Systems to facilitate effective delivery of remote classes. As mentioned earlier, industrial training courses have to be organized off campus at industrial sites to facilitate real time application of engineering theory and gain adequate exposure of professional experience much needed for enhancing transversal skills. In consideration of preventive measures and social distancing norms during the COVID19 pandemic, engineering programs have adopted course models that involve virtual or observatory roles for students instead of hands on field experience as previously available in training courses. In this paper, we introduce a novel course template blended with key elements of entrepreneurship as per the national Saudi 2030 Vision [27] for conducting industrial training courses during the COVID19 pandemic. Since virtual or observatory roles cannot offer the same level of rigor regarding real time practical experience or transversal skills as compared to that gained from industrial sites, programs need to review other alternatives that can alleviate the learning gap in remotely offered virtual industrial training courses. A qualitative review of coverage of learning distribution of required Course Outcomes (COs) for virtual training courses can further help understand the degree of deficient learning. Considerable information is available in research literature [28,29,30] regarding several options for remote, simulation and virtual science and engineering laboratories that could be utilized by engineering programs to enhance learning in remotely offered virtual industrial training courses.

II. PURPOSE OF STUDY

The driving force behind this research is to examine the benefits of application of essential theory of the authentic OBE model for the implementation of a holistic and comprehensive educational process that maximizes opportunities for the attainment of successful student learning. The objective is to study remote assessment and evaluation of student learning activity using digital web-based platform EvalTools 6 ® for summer training courses of the electrical, mechanical and civil engineering programs.

In particular, the researchers sought to answer the following research questions:

1. Can web-based digital software be utilized for effective remote offerings of industrial training courses?
2. Do virtual engineering roles in remote offerings of industrial courses help students gain adequate practical experience and transversal skills?

III. THEORETICAL FRAMEWORK

Educational institutions following the OBE model should ensure all learning activities, assessments, evaluations, feedback, and advising, help students attain the targeted outcomes. As stated in [12,17], student learning activity in most training courses is not based on comprehensive outcomes and specific performance criteria with detailed analytic rubrics for valid and reliable assessment and evaluation. To better understand the scope of this research and the limitations of current training courses with outcomes-based approaches, we begin with a brief introduction to some essential elements of OBE which were developed by the *High Success Network* [11].

A. OBE Model

The keys to having an outcomes-based system are:

a) Developing a clear set of learning outcomes around which all of the educational system's components can be focused; and
b) Establishing the conditions and opportunities within the educational system that enable and encourage all students to achieve those essential outcomes.

OBE's two key purposes that reflect its "*Success for all students and staff*" philosophy are:

a) Ensuring that all students are equipped with the knowledge, competence, and qualities needed to be successful after they exit the educational system; and
b) Structuring and operating schools so that those outcomes can be achieved and maximized for all students.

B. Bloom's 3 Domains Taxonomic Learning Model and 3-Skills Grouping Methodology; Ideal Learning Distribution

Performance Indicators (PIs) should be specific to accurately assess learning activity related to a given course topic in any phase of the curriculum and aligned to a specific level of proficiency [15,16,18,22]. Fig. 1 shows the design flow for the creation of holistic learning outcomes and their PIs for all courses corresponding to introductory, reinforced and mastery levels spanning the curriculum [15].

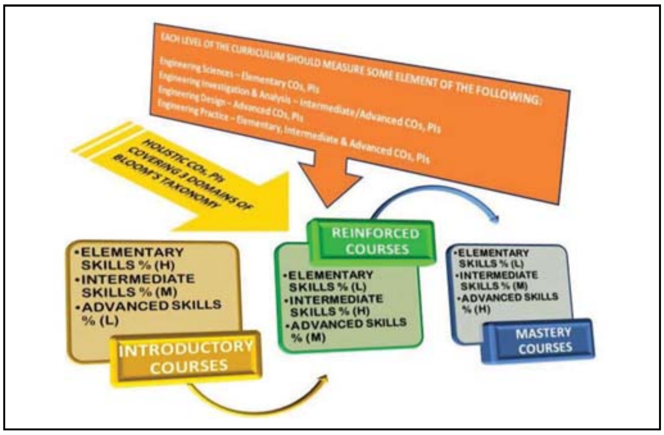

Fig. 1. Design flow for the creation of Advanced, Intermediate and Elementary COs, PIs covering 3 Domains of Bloom's Taxonomy

A novel *3-Level Skills Grouping Methodology* [15,16] as shown in Fig 2. was developed for each learning domain with a focus on grouping activities that are closely associated to a similar degree of skills complexity. COs and PIs designed following such an ideal distribution facilitate a thorough analysis of each phase of the learning process that result in comparatively easier mechanisms for early detection of student performance failures.

Skills Level	Cognitive Domain (Bloom, 1856; Anderson & Krathwohl, 2001)	Affective Domain (Krathwohl, Bloom & Masia, 1973	Psychomotor Domain (Simpson, 1972)
Elementary	1.Knowledge 2.Comprehension	1.Receiving phenomena 2.Responding to phenomena	1.Perception 2.Set 3.Guided response
Intermediate	3.Application 4.Analysis	3.Valuing	4.Mechanism 5.Complex overt response
Advanced	5.Evaluation 6.Creation	4.Organizing values into problems 5.Internalizing	6.Adaptation 7.Origination

Fig. 2. 3-Level Skills Grouping Methodology of Bloom's Revised Taxonomy

C. COs, PIs and Hybrid Rubrics

The Faculty of Engineering programs developed a state of the art digital database consisting of specific and generic PIs classified as per Bloom's 3 domains and their learning levels through a very exhaustive and elaborate ongoing process to comprehensively measure engineering activities corresponding to the ABET Engineering Accreditation Commission (EAC) SOs [15,16,22,23,31]. The PIs targeted assessment of various engineering activities corresponding to multiple skills levels in the introductory, reinforced and mastery level courses thus fulfilling Washington Accord engineering graduate knowledge, skills and professional competency profiles [16, 22, 23]. Design of COs and their PIs was meticulously completed following a *"design down"* mapping model [22] and using appropriate action verbs and subject content, thus rendering the COs, their associated PIs, and assessments at a specific skill level—elementary, intermediate or advanced. The essential aspects of COs and PIs design rules are listed below for better understanding of the potential for holistic results in teaching, assessment, evaluation and Continuous Quality Improvement (CQI).

***Rules for COs Design*:**

- Use operational action verbs to demonstrate the target learning activity that has to be assessed
- The COs can target multiple activities covering 3 domains of Bloom's model and the 3-levels skills elementary, intermediate and advanced. But, each activity would have to be assessed by corresponding PIs.
- The COs should sequentially cover all major course topics
- The COs for a specific topic should measure both theory and experimental lab skills to ensure comprehensive learning related to a given topic.
- Write moderately generic COs with context of several specific PIs that will measure various learning activities mentioned in the COs.

Rules for PIs Design:

- The PIs should be approximately aligned to the operational action verb and nominal subject content in COs.
- The PIs should be at a similar skills level as the corresponding activity in the CO.
- The PIs should align with the complexity and methods used in assessments planned to measure corresponding learning activities mentioned in the CO
- The PIs should use topic specific language in addition to that of COs and indicate names of techniques, standards, theorems, technology, methodology etc.
- The PIs should provide major steps to analyzing, solving, evaluating, classifying etc. so they can be utilized to develop hybrid rubrics
- Several PIs should be used to assess multiple learning activities relating to multiple domains and 3-levels skills

Fig. 3 shows a detailed COs design methodology for a summer training course EE 390. The COs were meticulously developed to target essential learning of industrial training activity such as problem solving, design, experimentation, using new tools/equipment/software, teamwork, observing professional ethics and safety standards.

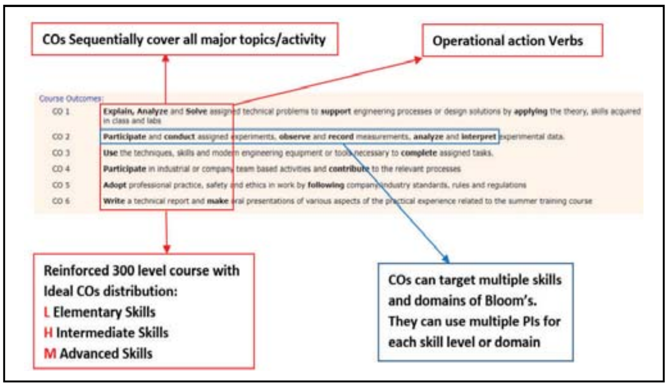

Fig. 3. Detailed COs design methodology for summer training course

Table 1 shows how holistic course delivery is achieved using accurate alignment of COs and their specific PIs which are classified according to Bloom's 3 learning domains and their learning levels. For instance, both CO3 and PI_6_42 are classified as a psychomotor domain of learning and aligned to an *adaptation* learning level. This format for COs design facilitates a holistic delivery of industrial training courses by appropriate selection of learning domains and learning levels for various activities to ensure *Mastery Learning* by using an ideal learning distribution [22]. Detailed topic specific hybrid rubrics which combine both analytic and holistic content are used to guide students for effective management of training activity and accurate estimation of their expected performances [22]. Fig. 4 shows a sample hybrid rubric for PI_4_8: *Fulfill Implementation of safety and health requirements in assigned processes as per required company/industry standards or regulations.*

Choose an Assignment/Quiz for Grading: FINAL REPORT_SAFETY_STANDARDS | Select >>

Key Assignment: Yes

Grading Criteria:

PI	E	A	M	U
abet_PI_4_8: Fulfill Implementation of safety and health requirements in assigned processes as per required company/industry standards or regulations	**Excellent (90-100%)** (25%) Proper implementation of recommended and mandatory safety gear. (25%) Professional operation of instruments/equipment/devices as per manufacturer's/industry safety regulations (25%) Maintain safe position and location for operation of instruments/ equipment/devices by considering self, public safety and location ergonomics (25%) Diligent following and perfect implementation of all instructions of the site training supervisor	**Adequate (75-89%)** (25%) Partial implementation of recommended safety gear. (25%) Professional operation of instruments/equipment/devices as per manufacturer's/industry safety regulations (25%) Maintain safe position and location for operation of instruments/ equipment/devices by considering self, public safety and location ergonomics (25%) Minor lapse to diligently follow and perfect implementation of all instructions of the site training supervisor	**Minimal (60-75%)** (25%) Partial implementation of recommended safety gear. **AND/OR** (25%) Some lack of professional operation of instruments/equipment/devices as per manufacturer's/ industry safety regulations **AND/OR** (25%) Maintain safe position and location for operation of instruments/ equipment/devices by considering self, public safety and location ergonomics **AND/OR** (25%) Minor lapse to diligently follow and perfect implementation of all instructions of the site training supervisor	**Unsatisfactory (0-60%)** (25%) Improper implementation of recommended and mandatory safety gear. **AND/OR** (25%) Lack of professional operation of instruments/equipment/devices as per manufacturer's/industry safety regulations **AND/OR** (25%) Unable to maintain safe position and location for operation of instruments/ equipment/devices by considering self, public safety and location ergonomics **AND/OR** (25%) Major lapse and deficiency to diligently follow and perfect implementation of all instructions of the site training supervisor

Fig. 4. Hybrid rubric for implementing safety and health regulations during industrial training

TABLE I. INDUSTRIAL TRAINING COURSE DELIVERY USING COS AND ASSOCIATED PIS

Class: EE_390_276 Summer Training Size: 18	
CO 1 Problem solving /Design	**Explain, Analyze** and **Solve** assigned technical problems to **support** engineering processes or design solutions by **applying** the theory, skills acquired in class and labs
[abet_PI_1_103] Cognitive: Analyzing Observe and practice real engineering problem solving in an engineering industrial environment	
CO 2 Experimentation	**Participate** and **conduct** assigned experiments, **observe** and **record** measurements, **analyze** and **interpret** experimental data.
[abet_PI_6_18] Psychomotor: Adaptation Participate in assigned experiments, observe & record measurements, operation of appropriate test and experimental equipment's, analyze and interpret data	
CO 3 Tools & Techniques	**Use** the techniques, skills and modern engineering equipment or tools necessary to **complete** assigned tasks.
[abet_PI_6_42] Psychomotor: Adaptation Complete tasks assigned by your supervisor or team by using appropriate techniques, skills and modern engineering equipment or tools related to various industrial manufacturing/design/failure analysis/testing and maintenance processes; study company procedures, technical documentation, data sheets, operating instructions; document practical engineering experiences necessary to complete assigned tasks	
CO 4 Teamwork	**Participate** in industrial or company team based activities and **contribute** to the relevant processes
[abet_PI_5_10] Affective: Internalizing values Communicate effectively with assigned supervisors, team members and other stake holders; listen to given instructions; listen to others in the team and create a supportive team environment; effectively coordinate tasks with other team members; and complete assigned tasks in a timely manner	
CO 5 Professional ethics & Safety	**Adopt** professional practice, safety and ethics in work by **following** company/industry standards, rules and regulations
[abet_PI_4_8] Affective: Internalizing values Fulfill Implementation of safety and health requirements in assigned processes as per required company/ industry standards or regulations	
CO 6 Reports & Presentation	**Write** a technical report and **make** oral presentations of various aspects of the practical experience related to the summer training course
[abet_PI_3_9] Affective: Internalizing values Make effective oral presentations in a given time frame to defend field experience activity with required: professionalism, style, slide quality, delivery, response to questions; title, front matter, appropriate English(grammar/spelling/sentence structure); abstract/introduction; description of training program mission or goal of the summer training course; formal introduction of the company visited, relevant training processes; completion of assigned tasks; professional development and overall contribution to field training activities such as case studies/measurements/supervision and design, theory and field applications, research activities, conclusions & recommendations etc.	
[abet_PI_3_1] Affective: Internalizing values Write complete technical reports following appropriate standards, format and style with: title, front matter, list of tables and contents; details of overall organization of the report; proper English(grammar/spelling/sentence structure); neatly labeled sketches/diagrams; abstract/introduction; description of training program mission or goal of the summer training course; formal introduction of the company visited, relevant training processes; completion of assigned tasks; professional development and overall contribution to field training activities such as case studies/measurements/supervision and design, theory and field applications, research activities, conclusions & recommendations etc.	

D. Performance Criteria

A structured Faculty Course Assessment Report (FCAR) integrated with PIs uses the Excellent, Adequate, Minimal and Unsatisfactory (EAMU) performance levels in rubrics [15,24]. The EAMU scales are utilized in embedded online assessments to estimate the outcomes results for training performances. Details of EAMU performance scales and a scientific color coded flagging mechanism with heuristic rules is shown below in Table II.

TABLE II. EAMU PERFORMANCE SCALES AND COLOR CODED FLAGS FOR HEURISTIC RULES

Specification of EAMU performance indicator levels:	
Category –Scale%	**Description**
Excellent (E) (90 – 100)	Apply knowledge with virtually no conceptual or procedural errors
Adequate (A) (75 - 90)	Apply knowledge without significant conceptual errors and only minor procedural errors
Minimal (M) (60 – 75)	Apply knowledge with occasional conceptual errors and only minor procedural errors
Unsatisfactory (U) (0 - 60)	Significant conceptual and/or procedural errors when applying knowledge
Heuristic rules for Performance Vector Tables (PVT):	
Category	**General Description**
Red Flag	Any performance vector with an average below 3.3 and a level of unsatisfactory performance (U) that exceeds 10%
Yellow Flag	Any performance vector with an average below 3.3 or a level of unsatisfactory performance (U) that exceeds 10%, but not both
Green Flag	Any performance vector with an average that is at least greater than 4.6 and no indication of unsatisfactory performance (U)
No Flag	Any performance vector that does not fall into one of the above categories

IV. RESEARCH METHOD

This research paper involves study of implementation of state of the art digital technology with cutting edge OBE assessment methodology to remotely deliver holistic industrial training courses. Students are guided throughout the various phases of the industrial work by their training advisors using a versatile online *Biweekly Reporting* tool which is tightly aligned with the COs, PIs and hybrid rubrics. This helps students to remain focused on key learning areas aligned with the intended COs at industrial sites while continuously gauging their performance using rubrics related to each learning activity [25,31]. The *FORUM* tool effectively facilitates communication of individual and group experiences across industrial sites to catalyze collaborative work [25,31]. The performance data for COs and PIs is collected using direct and indirect assessments. The FCAR summative and formative data is quite detailed and for brevity samples of the assessment mechanism are presented in this paper. The course level CQI process dealing with ported old actions, reflections and follow up new actions are also shown. Some essential features of paperless reporting and documentation are displayed. Table III shows number of participating students and industrial sites remotely managed for industrial summer training courses from 2016-20 with EvalTools ® for the EE, ME and CE programs. We then present a course template specially designed and implemented in summer of 2020 for virtual offerings of industrial courses during the COVID19 pandemic. In conclusion, a comparison of the two course models is made and limitations of industrial training course offering during current pandemic conditions and some plausible recommendations for enhancing holistic learning are discussed.

TABLE III. INDUSTRIAL TRAINING PARTICIPANTS AND SITES 2016-20

Program		2016	2017	2018	2019	2020*
EE	Students	20	11	3	15	18
	Sites	5	3	3	12	4
ME	Students	18	17	6	19	19
	Sites	11	10	5	13	4
CE	Students	9	9	19	25	3
	Sites	6	4	13	14	1

*COVID19 course template implemented with virtual student roles

A. Assessment Methodology

The Faculty of Engineering implemented state of the art digital technology and assessment best practices to achieve holistic course delivery with realistic CQI. The following points summarize the essential elements of the integrated quality management system employed to effectively deliver remote industrial training courses:

1. OBE assessment model

2. ABET, EAC outcomes assessment model employing Program Educational Objectives (PEOs), 7 SOs and PIs to measure COs.

3. The FCAR utilizing the EAMU performance vector methodology [15,16,22,23,24].

5. Well-defined performance and heuristics criteria for course and program levels [15,24].

6. A digital database of specific PIs classified as per Bloom's 3 domains of learning and their associated levels [15,16,22,23].

7. Unique Assessments mapping to one specific PI [23].

8.Scientific Constructive Alignment for designing consolidated assessments aligned to specific PIs [16,23,31].

9. Integration of direct, indirect, formative and summative outcomes assessments for course evaluations [16].

10. Calculation of course level ABET SOs, COs data based upon weights assigned to various types of assessments, PIs and course levels [15,16].

11. Online *Biweekly Reporting* tool to guide and assess students with COs, PIs and their hybrid rubrics [15,31].

12. Online *FORUM* communication and collaboration tool to integrate feedback with course management [15,31].

B. FCAR, EAMU Performance Vector Methodology and Web-based Software EvalTools® 6

Web-based software EvalTools® 6 provides electronic integration of Administrative Assistant System (AAS), Learning Management System (LMS), Outcomes Assessment System (OAS) and Continuous Improvement Management System (CIMS) facilitating streamlined faculty involvement for achieving realistic CQI. EvalTools® 6 [25] is chosen as the platform for outcomes assessment instead of Blackboard® since it is the only tool that employs the FCAR and EAMU performance vector methodology [24]. This methodology facilitates the use of existing curricular assignments for outcomes assessment to achieve a high level of automation of the data collection process. The EvalTools® 6 FCAR module provides summative/formative options and consists of the following components: course description, COs indirect assessment, grade distribution, course reflections, old action items and new action items, COs direct assessment, PIs assessment, SOs assessment, assignment list, learning domains and skills levels assessment distribution [15,16,22,23,24]. The FCAR uses the EAMU performance vector, conceptually based on a performance assessment scoring rubric, developed by Miller and Olds [26], to categorize aggregated student performance. Heuristic rules and indicator levels for EAMU performance vector have been explained in research work related to the FCAR [15,24].

V. RESULTS

In this section, we present some results of remote offering of industrial training courses by highlighting specific features of the biweekly reporting, FORUM, FCAR assessment and evaluation modules.

A. Biweekly Reporting Tool

The *Biweekly Reporting* tool is the most important online feature of EvalTools ® used by instructors to remotely manage and guide the student industrial training activity. It ensures students remain focused on essential areas of learning such as problem solving, design, experimentation, teamwork, observing professional ethics and safety regulations [25,31]. Fig. 5 shows a sample of the ME program's industrial training activities aligned to COs, PIs for experimental work and guided remotely by advisors. The report consists of three sections dealing with i) *Training Site Information* ii) *Training Aspects Related to COs* and iii) *General Questions*.

Fig. 5. Biweekly reports aligned to COs and PIs for managing and assessing student industrial training activities

B. FORUM Tool

The FORUM tool is an effective communication and collaboration platform for integrating feedback from industrial training students to course assessment. Students post individual and group experiences and communicate with their colleagues, other teams and their advisors. Advisors are able to post comments, activity, follow up on any query and congratulate student achievements. A comprehensive rubric for grading posts on the FORUM is available for view and application to both students and their advisor [25,31].

C. FCAR Assessment, Evaluation and CQI

As shown in Fig. 6, the FCAR presents several comprehensive reports displaying scientifically color coded, consolidated COs, SOs, PIs histogram plots, summative learning distribution data, and CQI information [15]. Detailed students' EAMU performance results for various assessments linked to each CO are listed sequentially [23]. The FCAR assessment and evaluation reports are comprehensive and details of which cannot be covered by the scope of this paper

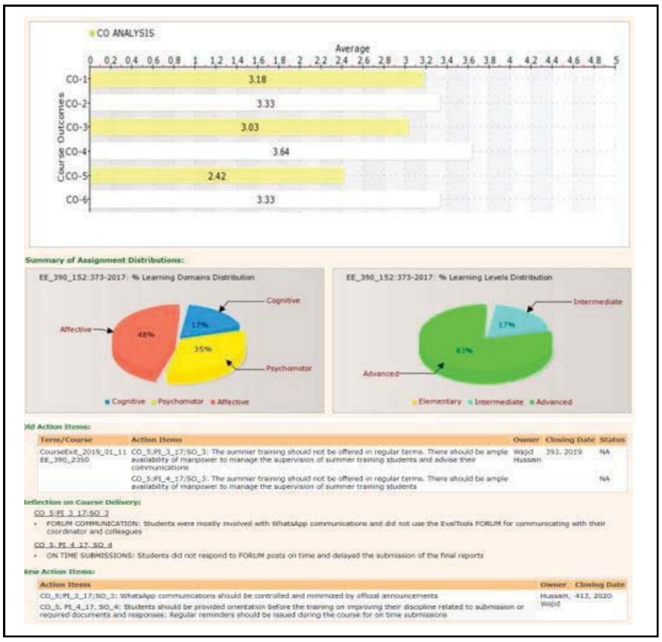

Fig. 6. . Section of FCAR evaluation report showing consolidated COs plot, learning distribution and CQI information

VI. Training Course Template During COVID19

In many countries, current pandemic conditions have limited mobility and routine business activity. The education sector in particular, has drastically shifted to online digital solutions as a substitute for regular in-person class, training, examination or administrative activity. Especially, off campus industrial training courses could not offer students the privilege of direct physical participation in onsite engineering activity. To make up for the loss in learning due to lack of direct industry exposure, we present a course template that would offer students a reasonable remote and virtual learning experience as an alternative to an onsite in-person participation. As shown in Table III, this course template was offered to 40 engineering students in the summer term of 2020. Assessment of various activity was carried out by the vocational committee and the advisor. The COs and PIs for this template remain unchanged. However, the assessment criteria are modified. A set of criteria was outlined for qualification of the training plan:

1. Training plan should be relevant to the area of specialization and comprehensively cover all COs.
2. Training plan should involve virtual observation and remote participation of relevant engineering activity.
3. Industrial organization for summer training can be designated by recommendation of advisor and/or student selection.

The criteria for an acceptable organization are:

1. Availability of an authorized industry supervisor; and/or
2. Availability of industry related training activity and associated information on public domain; and
3. Sufficient training information to comprehensively cover all COs.

TABLE IV. Assessment Policy - Virtual Training Course

Assessment	% Total Grade	Passing Grade	Action if Not Passed
Training Plan Evaluation[VC]	15%	9 %	Repeat training
Interim Evaluations 1&2[A] (viva 3rd & 6th weeks)	12 %	18 %	-
Bi-weekly Reports (1-4)[A]	12 %		
FORUM Communication[A]	4 %		
Timely Report Submission[A]	2 %		
Final Written Report[VC]	25%	15%	Resubmit report
Oral Presentation[VC]	30%	18%	Repeat presentation

VC Vocational Committee; A Advisor

Table V shows the schedule for a comprehensive training plan consisting of 11 phases. A top down approach is adopted to instill a holistic industrial learning experience blended with key elements of entrepreneurship as per the Saudi Vision 2030 [27]. The students begin with reviewing the history of the industry, organization, organizational structure, business model and target markets. They then select a department and virtual engineering role to work in. Students construct the operational structure and process flow of their department using information either directly from the organization's website or extracted from other sources on the public domain such as research literature, technical blogs or YouTube videos. The professional engineering experience I & II involve problem solving, design, experimentation, teamwork activity for which students employ remote labs or virtual training roles to simulate relevant activity approved by advisors. According to research [28, 29, 30], several options for remote, simulation and virtual laboratories are available and offered by either established universities or other private and governmental initiatives such as Virtual Labs ® by EDX, V-labs ®, Virtual Engineering ®, Labster ®, Praxilabs ® etc. In phase 10, students critically analyze their virtual engineering experience by comparing key aspects of the work environment for their organization, with that of a competitor. Finally, they submit a final report as per given template and make remote streaming video presentations in defense of their training experience.

TABLE V. Schedule of Phases. Learning Activity and Assessment for Summer Training Course with Virtual Student Roles

Week	Phase	Activity	Assessment	Resources
-1	**1. Assignment of Engineering Areas:** Vocational committee would provide a list of engineering areas to students to select their choice of industry for training.	Advisors assignment	N/A	Vocational Committee
-1	**2. Team Formation & Select Organization:** Form student summer training course teams of 3-4 students each; select organization for completing the summer training plan with access to sufficient information on public domain that comprehensively cover all subsequent phases listed below including all course outcomes; submit an initial training plan proposal with references that provide adequate information for completion of your summer training course.	1) Team formation 2) Select organizations which fulfill training plan requirements	N/A	Vocational Committee + Advisor + Web search
0	**3. Review and Approve Training Plan:** Vocational committee to review and approve teams and proposed training plans.	Finalization of training plan which covers all COs	Training Plan Proposal	Vocational Committee
1	**4. Overview of Industry and Organization:** Explain the history of industry and relation with area of engineering selected; history of organization, branches; commercial and/or scientific focus of organization; elaborate on the overall engineering concept(s) applied for commercialization; products and services; target markets; local and international competitors;	Collaborative Work, Research and Report	1. BWR1 2. Forum	▪ Web search ▪ Corporate web sites

2	**5. Organizational and Operations Structure and Flow:** Provide mission statement; organizational structure and hierarchy; elaborate on overall operational structure and process flow for delivery of final products and services; ISO status; quality standards of products and services; key aspects of organizational, operational ethics, team work; implementation of overall safety, and international or local regulatory standards followed;	Collaborative Work, Research and Report	1. BWR1 2. Forum	▪ Corporate web sites
3 & 4	**6. Overview of Major Departments and Operations:** Broadly overview role and functioning of major departments; operational structure and process flow for some key functions such as prototyping, large scale manufacturing, testing, research, engineering service; high level focus on engineering design, problem solving, experimentation; brief overview of application and use of novel technology, software and equipment; team work, professional ethics, quality standards, corporate culture;	Collaborative Work, Research and Report	1. Viva1 2. BWR2 3. Forum	▪ Corporate web sites ▪ Technical blogs ▪ YouTube
5	**7. Your Training Department and Role:** Select a specific department of the organization and virtual engineering position to work in; provide the mission statement of the this department; explain why you selected this department and position with consideration of your personal interests, academic strengths in relation to skills sets and knowledge areas, research and career prospects; describe the role of your department in the overall operational process of the organization; explain in detail the job function of the virtual engineering position you selected;	Collaborative Work, Research and Report	1. BWR3 2. Forum	▪ Corporate web sites ▪ Technical blogs ▪ YouTube ▪ Job sites (Linkedin)
6	**8. Professional Engineering Experience-I:** Observe, identify and report in detail engineering problem solving, design and experimentation processes and activity conducted in your department and role; explain state of the art technology, software or equipment you found in use and its benefits and/or limitations;	Collaborative Work, Virtual Observation, Remote Participation, Study and Report	1. Viva2 2. BWR3 3. Forum	▪ Corporate web sites ▪ Technical blogs ▪ YouTube ▪ Research Literature ▪ Virtual labs ▪ Training courses
7	**9. Professional Engineering Experience-II:** Use any purchased or open source tools, software for simulating some engineering activity relevant to your role and explain your experience; elaborate on the Quality Assurance process and list any ISO, safety or other regulatory codes followed in your department and role; observe, identify and report professional ethics, team work and corporate culture exhibited in your department and role;	Collaborative Work, Virtual Observation, Remote Participation, Study and Report	1. BWR4 2. Forum	▪ Corporate web sites ▪ Technical blogs ▪ YouTube ▪ Research Literature ▪ Virtual labs ▪ Training courses
8	**10. Critical Analysis:** Critically compare any aspect(s) of this department's engineering activity, equipment, process or work environment with that of another organization; elaborate on any risks or hazards you were exposed to; critically analyze the final product, service with respect to realistic constraints such as economic, environmental, safety/health, sustainability, political, societal etc.; explain what you liked about your role, any possible caveats to working in this department or organization; provide any recommendations for improvement; list any possible research topics that you could identify for your final year Capstone Design Project;	Collaborative Work, Critical Analysis and Report	1. BWR4 2. Forum	▪ Corporate web sites ▪ Technical blogs ▪ YouTube ▪ Research Literature
9	**11. Submit Final Report and Make Oral Presentations:** Submit final report; cover all aspects of the 6 phases (2-8) of your summer training activity as per given template; include the phase 8 into conclusions of your report; make an elaborate streaming video presentation of your summer training experience; cover all 8 phases while comprehensively addressing all the course outcomes; provide adequate references of all citations to information related to the organization;	Report and Video Presentation	Final Report & Presentation	▪ Final report & Presentation template

VII. Discussion and Conclusion

The purpose of this study is to examine the benefits and limitations of using an outcome based digital platform for remote offering of industrial training courses. As per the literature review presented in the introduction to this paper, remote management of industrial courses is a complex affair and requires advanced digital technology and supporting assessment methodology to implement holistic learning. The most intricate part is to remotely manage and assess student training activity according to the intended COs in an off campus location. The *Biweekly Reporting*, collaborative *FORUM* tools and remote employer online surveys are specially designed to ensure that the COs are integrated with every major phase of training to help advisors guide students in a progressive manner and achieve *Mastery Learning*. Automatically generated real-time performance information and state of the art features for effective monitoring and on time feedback facilitate seamless alignment of student learning activity with the intended COs. The Faculty of Engineering EE, ME and CE programs successfully managed training activity for 171 students remotely by using web-based software EvalTools ® during the years 2016-19 at 99 regional and international industrial sites.

Onsite in-person training provides holistic learning opportunities involving hands-on practical experience and required exposure to professional ethics, collaborative work and quality standards related to real-life engineering situations at industrial sites that cannot be adequately gained in virtual roles. The Office of Quality and Accreditation performed a qualitative analysis of the learning distribution coverage in Bloom's 3 domains for COs related to onsite and virtual offerings of industrial training courses by collecting feedback from two leading international OBE and assessment experts. The results of this analysis in Table VI show that excepting for a medium (M) coverage for COs learning distribution in the cognitive domain, both psychomotor and affective domains exhibit a low (L) learning distribution. Therefore, adequate development of skills in the affective and psychomotor learning domains would be difficult to achieve in virtual training.

TABLE VI. COs Learning Distribution for Onsite and Virtual Offering of Industrial training Courses

CO	Onsite			Virtual		
	C	P	A	C	P	A
1 Problem solving, design	H	H	H	M	L	L
2 Experimentation	H	H	H	M	L-M	L
3 Techniques, Tools	H	H	H	M	L	L
4 Teamwork	H	H	H	M	L	L
5 Professional ethics, safety	H	H	H	M	L	L

C Cognitive P Psychomotor A Affective

However, engineering programs can still consider a virtual role as a viable, but temporary alternative to onsite training if the course plan would help students remotely achieve acceptable levels of cognitive learning related to problem solving, design, experimentation, professional ethics, and collaborative work at state of the art industrial sites. Adequate levels of cognitive learning have been achieved at IU by remotely conducting detailed case studies involving problem solving, design or experimentation in select engineering roles while focusing on fulfilment of specific quality standards and professional ethics. Essential aspects of this engineering activity were then replicated on a reduced scale using virtual labs, simulation or other tools.

Research Question 1: *Can web-based digital software be utilized for effective remote offerings of industrial training courses?* Yes. State of the art modules of EvalTools ® such as *Biweekly Reporting*, *FORUM*, digital database of PIs and hybrid rubrics, and FCAR facilitate effective management of remote course delivery, assessment and CQI.

Research Question 2: *Do virtual engineering roles in remote offerings of industrial courses help students gain adequate practical experience and transversal skills?* No. The results of a qualitative analysis shown in Table VI indicate that virtual roles can achieve acceptable levels of cognitive learning related to several essential elements of industrial training activity but cannot attain adequate learning distribution in both psychomotor and affective domains.

In summary, this study presents a viable but temporary alternative to onsite industrial training during global pandemic conditions by offering students a versatile course template that comprises of virtual engineering roles blended with essential entrepreneurial knowledge and skills.

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