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Review and Improvement of Learning Outcomes of Undergraduate Chemical Engineering Program: Curriculum 2024 Case Study

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Abstract. Institut Teknologi Bandung (ITB) has mandated several key changes in the general design framework of the Curriculum 2024. Several institution-wide mandatory courses centered around SDG and Industry 4.0 issues were implemented as a part of the 2025-2050 ITB Development Master Plan. This paper describes the review and improvement processes undertaken by the Chemical Engineering Undergraduate Program at ITB regarding its Program Educational Objectives (PEO) and its entire hierarchical learning outcomes. This review was undertaken in 2023-2024 as part of periodic outcomes assessment and evaluation (bottom-up approach) and to define the articulation of new mandatory courses and program offering variations required by ITB (top-down approach). The Curriculum 2019 version of PEO was deemed relevant for the next 5-10 years. Direct and indirect assessments of graduate learning outcomes (CPL) since 2019 indicated satisfactory overall attainment by the graduates and their relevance to the needs of employers. The Program-level outcomes were also deemed sufficiently flexible to accommodate ITB's current policies for the new curriculum. Minor revisions were undertaken on Graduate Sub-Learning Outcomes (Sub-CPL) to better align with the modern computational skillset requirements of the industry.

Keywords: Chemical Engineering, Continuous Improvement, Curriculum, Outcomes Assessment, Outcomes-Based Education, Undergraduate

INTRODUCTION

By facing contemporary challenges in the industry and society in general, chemical engineering science must be able to adapt its classical theories rooted in relevant engineering and scientific principles to solve problems in the modern industry. This integrated approach must encompass hands-on and problem-based learning that can effectively strengthen theoretical principles in future-oriented scenarios, which considers interdisciplinary learning. The integration of digital technology and data science, such as simulation-based experimentation, virtual laboratories, advanced data analyses, artificial intelligence, advanced instrumentation systems, and digital twins, is gaining importance element of chemical engineering education. Likewise, sustainable development

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is also rapidly being recognized as a necessary element of engineering education, particularly as an integral part of major design experiences (Gong *et al.*, 2024; Guerra, 2017).

Outcome-based education (OBE) is defined as a formal learning system in which all involved elements are designed in alignment to promote the attainment of a set of student learning outcomes. These outcomes are formulated by the academic programs and industrial and professional stakeholders to ensure their relevance. OBE and outcome-based accreditation have been recognized as major global trends in engineering education within the last century (Froyd *et al.*, 2012).

The last major revision of the ITB undergraduate Chemical Engineering curriculum was undertaken in 2013, primarily aimed at fully implementing OBE and accreditation criteria defined by ABET (Accreditation Board for Engineering and Technology), by which the Program was accredited in the 2010-2022 period. From 2015 to 2020, ITB implemented a continuously adaptable curriculum policy. Programs may propose minor changes (revision of course syllabi, repositioning of courses, etc.) or major changes (changes in Program learning outcomes, major restructuring of courses, major changes in course loads, etc.) as necessary. Eventually, no thorough review of the curriculum was undertaken within the period.

ITB is finalizing its 2025-2050 Development Masterplan (Rencana Induk Pengembangan 2025-2050), including a major redefinition of its education. ITB has structured the Curriculum 2024 guidelines in accordance with this Masterplan. The new curriculum represents a major departure from Curriculum 2013 and 2019, providing more alternative learning pathways for ITB students.

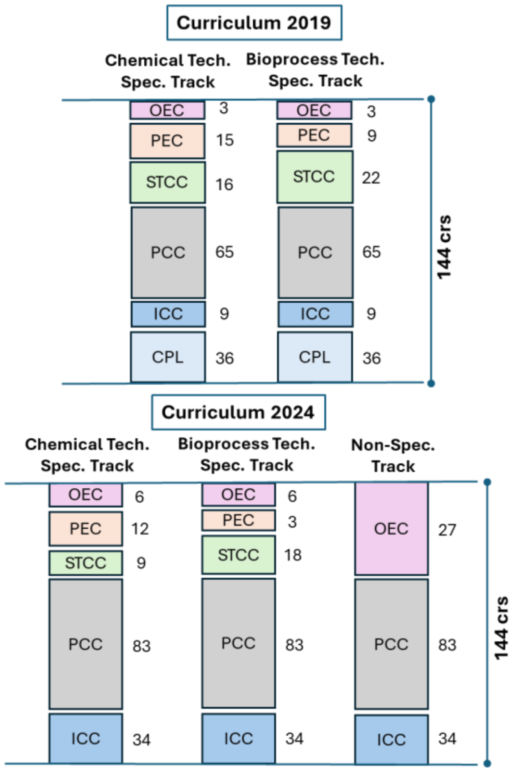

Fig. 1: Coursework structure of Curriculum 2019 and 2024
(CPL = common preparatory level,
ICC = ITB compulsory courses,
PCC = Program compulsory courses,
STCC = specialization track compulsory courses,
PEC = Program elective courses,
OEC = other elective courses)

Figure 1 compares the Chemical Engineering Undergraduate (UG) Program coursework structure at ITB. Curriculum 2024 provides more freedom for students to deepen or broaden their knowledge. The total coursework load has remained at 144 credits. According to Indonesian government regulation, it is the minimum load and is regarded by ITB as sufficient for a 4-year engineering UG program. Three optional tracks are offered: Chemical Technology Specialization, Bioprocess Technology Specialization, and Non-Specialization. The first two are designed to deepen chemical engineering subjects, while the latter – not available in Curriculum 2019 – is designed to maximize a flexible learning experience.

All three tracks provide the same coverage of ITB Compulsory Courses (ICC) and Program Compulsory Courses (PCC) to ensure that all graduates have the same core engineering competencies. Chemical Technology and Bioprocess Technology tracks differ in their composition of Specialization Track Compulsory Courses (STCC) and Program Elective Courses (PEC). In the Non-Specialization Track, all courses beyond ICC and PCC are categorized as Other Elective Courses (OEC) for maximum flexibility. This category may include in-program and off-program electives within ITB, exchange studies, internships, and others.

Key changes in core courses have been made to accommodate the curricular structure in Figure 1. These are summarized in Table 1. However, an exhaustive discussion of our Curriculum 2024 coursework design is too cumbersome to be included in this paper and is thus reserved for a dedicated paper in the near future.

A well-defined hiearchical structure of learning outcomes strongly characterizes OBE. This structure imposes a top-down hierarchy from Program Educational Objectives (PEO) to Program Learning Outcomes (PLO) and down to Course Learning Outcomes (CLO) (Yahya *et al.*, 2021). The current paper discusses the early and intermediate stages of Curriculum 2024 development of the Chemical Engineering UG Program at ITB. This stage involved the evaluation of previous Program Educational Objectives (PEO), assessment and relevance evaluation of Program Learning Outcomes (*Capaian Pembelajaran Lulusan / CPL*) associated Program Learning Sub-Outcomes (*Sub-Capaian Pembelajaran Lulusan / Sub-CPL*).

Table 1. Key coursework changes in Curriculum 2024

No.	Impacted courses / topics	Curriculum 2019	Curriculum 2024
1	ICC on biology	Industrial Microbiology (STCC)	Microbiology (ICC)
2	ICC on sustainability	Did not exist	Introduction to Principles of Sustainability (ICC)
3	ICC on AI literacy	Did not exist	AI & Data Literacy (ICC)
4	Analytical chemistry	Measurement & Analytical Methods	Expanded to Physical & Analytical Chemistry
5	Statistics	Chemical Engineering Statistics	Statistics & Experimental Design (some topics were moved to AI & Data Literacy)
6	Engineering math & computation	• Chem. Eng. Math. Analysis (2 crs) • Chem. Eng. Computation (3 crs)	Merged into Mathematics & Process Computation (4 crs)
7	Engineering economics & project management	Chem. Eng. Economics & Project Management (3 crs)	Split into Chem. Eng. Economics (2 crs, PCC) + Industrial Eng. Management (2 crs, ICC)
8	Process design	• Process Design (3 crs) • Process Performance Evaluation (2 crs)	Merged into Design & Analysis of Processing Systems (4 crs)
9	Capstone project	Chem. Eng. Plant Design (4 crs)	Chem. Eng. Plant Design (increased to 5 crs)

REVIEW OF PROGRAM EDUCATIONAL OBJECTIVES

Most academic program accreditation agencies associated with the Washington Accord multilateral recognition agreement define Program Educational Objectives (or PEO; also defined as Profile of Autonomous Professionals by IABEE or Indonesian Accreditation Board of Engineering Education) as broad statements describing competencies and attributes that will be attained by graduates of the Program several years after graduation. A program traditionally undertakes the formulation and review of PEO by Department-level committees by considering feedback from faculty members and the industry, which is typically represented by an Industrial Advisory Board (Abbadeni *et al.*, 2013).

The previous review of Chemical Engineering Undergraduate PEO was undertaken in 2021 considering the 2021-2025 Strategic Plan of the Faculty of Industrial Technology at ITB, results of assessment by the Program Quality Assurance Team, and discussions between faculty members and the Program Advisory Board. This review concluded that the 2019 PEO (PEO 2019) version was still academically and professionally relevant. Therefore, the currently used PEO 2021 is essentially identical to PEO 2019:

1. Progress in their professions by practicing chemical engineering principles and methods in technical, managerial, or other career tracks.
2. Be effective team members by applying and developing their communication and leadership skills.
3. Earn or are working towards advanced degrees in engineering, science, business, or other relevant areas of study, professional certifications, or are actively engaged in professional development activities in their employment.

For the development of Curriculum 2024, the PEO 2021 was again reviewed by including results from the Alumni User Survey undertaken by ITB in 2023, the vision and mission statement of the Faculty of Industrial Technology, and feedback from the Program Advisory Board.

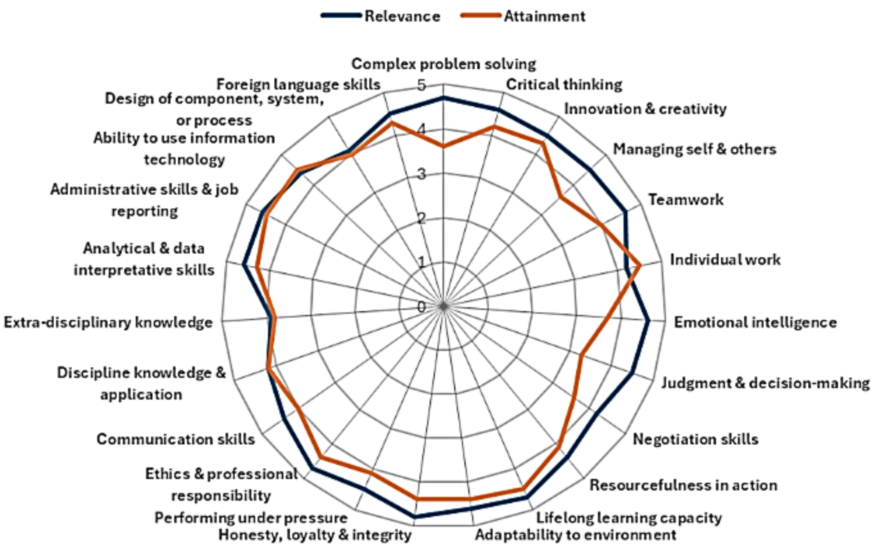

Fig. 2: Graduate attributes relevance and attainment of ITB Chemical Engineering UG alumni from ITB Alumni User Survey 2023 (n = 20 respondents)

The Alumni User Survey measured our alumni employers' perception of the relevance and attainment of specific graduate attributes. Figure 2 compares the relevance vs. attainment of 23 chemical engineering graduate attributes as perceived by employers. Employers were mainly represented by corporate human resource officers and business owners. The measurement used the Likert scale from 1 (highly disagree) to 5 (highly agree). Table 2 maps the 23 graduate attributes against the three PEOs.

Table 2. Mapping of graduate attributes measured in ITB Alumni User Survey 2023 against the Program Educational Objectives

No.	Graduate attributes measured by User Survey 2023	PEO 1	PEO 2	PEO 3
1	Complex problem solving	✓		
2	Critical thinking	✓		
3	Discipline knowledge & application	✓		
4	Innovation & creativity	✓		
5	Design of component, system, or process	✓		
6	Emotional intelligence		✓	
7	Negotiation skills		✓	
8	Communication skills		✓	
9	Administrative skills & job reporting		✓	
10	Foreign language skills		✓	
11	Honesty, loyalty & integrity		✓	✓
12	Professional ethics & responsibility		✓	✓
13	Extra-disciplinary knowledge		✓	✓
14	Management of self & others	✓	✓	
15	Teamwork	✓	✓	
16	Individual work	✓	✓	
17	Resourcefulness	✓	✓	
18	Adaptability to environment	✓	✓	
19	Performing under pressure	✓	✓	
20	Decision judgment & making	✓		
21	Analytical & data interpretative skills	✓		
22	Lifelong learning capacity			✓
23	Ability to use information technology			✓

Figure 2 indicates that our alumni employers gave nearly all of the 23 attribute items high relevance scores (4.0 or higher). Only one item received a score of < 4.0, namely extra-discipline knowledge (relevance score = 3.9). Most attributes were given attainment scores of less than their associated relevance scores. This discrepancy suggests the need for an overall Program-level learning improvement. However, at this stage the main concern was judging the relevance of PEO 2021 for adoption in the Curriculum 2024.

Combined with the PEO vs. graduate attributes mapping in Table 2, User Survey 2023 indicated that PEO 2021 was still relevant to the demands of the chemical engineering profession and that their attainment by our graduates has been satisfactory (with attainment scores >3.50). Feedback from our Program Advisory Board, which comprises 13 members representing the Program Alumni Association, ITB Board of Trustees, startup businesses, chemical industrial corporations, and engineering consultants, also indicated the relevance of PEOs formulated in 2021 to be implemented in Curriculum 2024.

REVIEW OF PROGRAM LEARNING OUTCOMES IN CURRICULUM 2019

The current Chemical Engineering Undergraduate Program Learning Outcomes (PLO) resulted from a major revision during the implementation of the Curriculum 2019. The PLO restructurization followed the change implemented by ABET for engineering academic programs accreditation criteria, which reorganized the 11-item student outcomes into 7-item outcomes. The PLOs implemented for Curriculum 2019 are summarized in Table 3. The Program has implemented a clearly defined hierarchy of PEO, PLO, and CLO, ensuring a constructive alignment between the three levels of learning outcomes. The outcomes breakdown structure is also summarized in Table 3. Each PLO is divided into several Sub-PLOs, which are divided into several highly measurable CLOs.

A critical element in OBE is the assessment of learning outcomes, defined as the measurement of the attainment of prescribed knowledge, skills, and attributes by students upon the conclusion of a learning unit (a course or a program). Outcomes assessment allows a teacher or a Program to measure the effectiveness of learning materials and methods and student involvement in the learning process. The importance of assessment in OBE is reflected in the paradigm of 'assessment drives learning' (Lavanya & Murthy, 2022).

In higher education, the assessment of learning outcomes is defined as the systematic process of collecting, reviewing, and using information related to academic programs to improve student learning based on measures of student performance. For this purpose, assessment also focuses on curriculum and student performance as groups (Palomba & Banta, 2015; Ewell, 1998; Tam, 2014).

Periodic assessment of the Chemical Engineering UG PLO is primarily based on course-level direct instruments associated with the outcomes breakdown structure in Table 3. For brevity, only the list of targeted courses is included; CLOs associated with each targeted course are excluded. Altogether, 125 CLOs throughout the curriculum are measured annually to produce a complete PLO assessment within an academic year. The assessment criterion of CLO attainment as an indicator of learning effectiveness is the proportion of students achieving scores at least 75% of the relevant CLO performance indicators. This minimum level of performance approach ensures that students meet graduation requirements as stipulated by IABEE accreditation criteria (IABEE, 2023). An example of a similar approach is the assessment guideline implemented by Ohio State University (OSU, 2024).

In addition to direct assessment based on the learning outcomes structure in Table 3, the PLO assessment also incorporate several indirect assessments. These are Exit Surveys undertaken by the Chemical Engineering Undergraduate Program Quality Assurance Unit, and Alumni Survey and Alumni Users Survey administered annually by the ITB Student Directorate office.

The Exit Survey is administered for fresh graduates as an online form, which includes Likert-scale multiple-choice questions and textual entries. The survey has been administered regularly since 2012. The survey assesses a wide range of aspects to gauge the overall learning experience and effectiveness, including self-assessment of the graduates' PLO attainment. The mapping of each PLO item to associated Exit Survey questions is summarized in Table 4. These questions employ the 1 to 4 Likert scale, with 1 = undeveloped / disagree and 4 = highly developed / highly agree.

Table 3. Program learning outcomes breakdown structure in Curriculum 2019

PLO	Sub-PLO	Targeted Courses	Number of Associated CLOs
(1) Ability to identify, formulate, & solve complex engineering problems by applying	(1-1) Ability to apply concepts of integral & differential calculus and/or statistics to solve chemical engineering problems.	Mathematics 1A + 2A, Chem.Eng. Mathematical Analysis, Chem.Eng. Statistics	11

PLO	Sub-PLO	Targeted Courses	Number of Associated CLOs
mathematics, science, & engineering.	(1-2) Ability to apply formulations & basic concepts in mass & energy balance, thermodynamics, heat transfer, mass transfer, fluid mechanics, reaction kinetics, separation, process control in chemical engineering problems.	Elementary Physics 1A+2A, Basic Chemistry 1A+2A, Mass & Energy Balance, Chem.Eng. Thermo-dynamics, Fluid & Particle Mech., Chem. Reaction Eng., Heat Transfer Ops., Separation Processes, Transport Phenomena, Process Control	24
	(1-3) Ability to construct appropriate strategy to identify & solve engineering problems, including process design & application of engineering in realistic conditions.	Industrial Intership, Interdisciplinary Project for Chem.Eng., Process Design, Process Performance Evaluation, Chem. Product Design	8
	(1-3) Ability to integrate scientifi and/or mathematical principles to construct models of chemical, physical, and/or biological processes & of systems relevant to chemical engineering.	Chem.Eng. Mathematical Analysis, Chem. Reaction Eng., Transport Phenomena, Process Control, Process Plant Safety	8
(2) Ability to design systems, components, or processes to fulfill needs under realistic constraints, by	(2-1) Ability to analyze & design chemical engineering unit operations, including complex integrated systems consisting of multiple unit operations.	Heat Transfer Ops., Separation Processes, Process Design, Chemical Plant Design, Bioprocess Plant Design	9
considering impacts of engineering solution in global, economic, environmental, & social context.	(2-2) Ability to analyze constraints such as economic, safety, health & environmental considerations in process systems design.	Process Design, Process Plant Design, Bioprocess Plant Design	5
(3) Ability to commu-nicate effectively with diverse audience.	(3-1) Ability to effectively commu-nicate in written manner	Chem.Eng. Elementary Lab, Process Technology Lab, Bioprocess Technology Lab, Industrial Intership, Chemical Plant Design, Bioprocess Plant Design	6
	(3-2) Ability to effectively commu-nicate in verbal manner	Chem.Eng. Elementary Lab, Process Technology Lab, Bioprocess Technology Lab, Industrial Intership, Chemical Plant Design, Bioprocess Plant Design	6
	(3-3) Ability to adjust presenta-tion content & style to audience.	Interdisciplinary Project for Chem. Eng., Chem. Eng. Research I & II	3
(4) Ability to realize professional & ethical responsibilities in	(4-1) Understanding of ethical & professional responsibilities ascpects of chemical engineering	Industrial Internship, Chem.Eng. Professional Seminar	2
engineering problem solving & decision-making based on	(4-2) Understanding the impact of global, economic, environmental, & social issues within the context of	Environ. Management in Chem. Industry, Industrial Internship, Interdisciplinary Project for Chem.Eng.,	7

PLO	Sub-PLO	Targeted Courses	Number of Associated CLOs
information, by con-sidering engineering solution impact in global, economic, en-vironmental, & social contexts.	an engineering solution	Chem.Eng. Professional Seminar, Chem.Eng. Economics & Project Management	
(5) Ability to parti-cipate effectively in teams, in which mem-bers create leadership & collaborative & inclusive environment, define objectives, plan tasks, & achieve goals.	(5-1) Demonstrate teamwork capability (in multidisciplinary & multicultural environment), either as team leader or member.	Chem.Eng. Elementary Lab, Process Technology Lab, Bioprocess Techno-logy Lab, Industrial Intership, Interdisciplinary Project for Chem.Eng.	5
	(5-2) Ability to define objectives & to plan tasks	Chem.Eng. Elementary Lab, Process Technology Lab, Bioprocess Technology Lab, Chem.Eng. Research I	4
(6) Ability to design & conduct experiments, analyze & interpret data, & to employ technical considera-tions to formulate conclusions.	(6-1) Follow & construct experi-mental protocols by observing safety aspects	Measurement & Analytical Methods, Chem.Eng. Elementary Lab, Process Technology Lab, Bioprocess Technology Lab, Chem.Eng. Research I & II	7
	(6-2) Ability to statistically analyze & interpret experimental data	Chem.Eng. Elementary Lab, Process Technology Lab, Bioprocess Tech-nology Lab, Chem.Eng. Research II	6
(7) Ability to learn & apply new knowledge to support own needs, with appropriate learning strategies.	(7-1) Understanding the need for lifelong learning	Chem.Eng. Research I & II, Chem.Eng. Professional Seminar	3
	(7-2) Utilize personal computers for engineering calculations, using programming language or spreadsheets.	Chem.Eng. Statistics, Chem.Eng. Computation	6
	(7-3) Utilize modern process simulation software package to design & evaluate chemical engineering processes.	Process Control, Process Design, Process Performance Evaluation	3
	(7-4) Utilize modern technical libraries to search journal articles, textbooks, & references required for engineering practice.	Chem.Eng. Research I & II	2

Table 4. Mapping of PLO against Exit Survey questions

PLO no.	Exit Survey question
1	a. Combine math and/or scientific principles to construct chemical, physical, and/or biological process models in chemical engineering. b. Apply differential & integral calculus and/or statistics to solve chemical engineering problems. c. Apply concepts & fundamental correlations in mass & energy balance, thermodynamics, heat transfer, mass transfer, fluid mechanics, chemical reaction engineering, separation process, and/or process control in chemical engineering problems. d. Integrate chemical engineering, mathematics, science, & other engineering aspects into engineering

PLO no.	Exit Survey question
	problem solutions.
	e. Develop appropriate strategies to identify & solve engineering problems, including applying engineering principles to practical problems.
	f. Identify & utilize appropriate resources to solve problems.
	g. Take assumptions to solve practical problems & to evaluate the validity of the solution.
	h. Utilize computers to perform engineering calculations, prepare documents & presentations, & access information from databases or the internet.
	i. Conduct process simulations using modern process simulator software packages.
	j. Utilize modern libaries to search journal articles, textbooks, & other references required for engineering practice.
2	a. Analyze & design chemical engineering unit operations, including systems involving more than 1 unit operation
	b. Construct a basic design of the processing system as process flow diagrams by applying heuristics for process design & mass & energy balance calculations, including constitutive equations (phase equilibria, reaction kinetics, etc.)
	c. Evaluate the economic feasibility of projects based on cashflow analysis & commonly used profitability indicators.
	d. Identify social, economic, environmental, & cultural problems that may become constraints in process design.
3	a. Prepare written communications (reports, presentations, etc.) using appropriate & effective language.
	b. Able to communicate ideas & arguments verbally using appropriate & effective language.
	c. Adjust content & style of presentation to specific audiences
4	a. Aware of & able to analyze chemical engineering professional ethics issues.
	b. Understand the impact of the chemical engineering profession on society.
	c. Understand the importance of professionalism & service to the profession.
	d. Understanding of political, demographic, economic, & environmental issues.
	e. Understanding of the impact of engineering decision on the environment & local & global socio-economy.
	f. Understanding cultural aspects beyond one's own place of origin.
	g. Identify & analyze contemporary issues in economy, politics & environment.
	h. Understanding the impact of technology on local, national, & international issues.
5	a. Describe chemical engineering problems & unique solutions to audiences from other disciplines.
	b. Gain knowledge of technical skills, problems, & approaches from other disciplines.
	c. Solve problems by collaborating with peers from other disciplines.
	d. Lead effectively by leveraging skills of people from other disciplines.
6	a. Follow experimental procedures by practicing work safety.
	b. Operate experimental equipment according to standard procedures.
	c. Apply statistics to determine confidence intervals, test for significant differences, & determine the significance of experimental variables to measured results.
	d. Design & conduct experiments to test hypothesis.
	e. Analyze & interpret experimental data.
7	a. Utilize various educational media e.g., textbooks, scientific journals, the internet, educational software, & library systems in general.
	b. Recognize professional support systems available for graduates: professional associations, technical communities, professional training, etc.
	c. Awareness of the dynamics of science & technology, & the continuity of education after graduation.
	d. Able to learn in an independent manner.

Table 5. Mapping of ITB Alumni Survey competency items to Chemical Engineering Undergraduate Program Learning Outcomes

No.	Graduate attributes measured by User Survey 2023	PLO 1	2	3	4	5	6	7
1	Complex problem solving	✓						
2	Critical thinking	✓						
3	Discipline knowledge & application	✓						
4	Innovation & creativity		✓					
5	Design of component, system, or process		✓					
6	Emotional intelligence			✓				
7	Negotiation skills			✓				
8	Communication skills			✓				
9	Administrative skills & job reporting			✓				
10	Foreign language skills			✓				
11	Honesty, loyalty & integrity				✓			
12	Professional ethics & responsibility				✓			
13	Extra-disciplinary knowledge				✓			
14	Management of self & others					✓		
15	Teamwork					✓		
16	Individual work					✓		
17	Resourcefulness					✓		
18	Adaptability to environment					✓		
19	Performing under pressure					✓		
20	Decision judgment & making						✓	
21	Analytical & data interpretative skills						✓	
22	Lifelong learning capacity							✓
23	Ability to use information technology							✓

The annual Alumni Survey administered by the ITB Student Directorate office includes 23 competency items. For each competency item, respondents are asked to rate three aspects: (1) attainment of competency by the alumni, (2) contribution of education in ITB to the attainment, and (3) significance of the competency for the alumni's present occupations. These competency items are then mapped to the seven PLOs, as summarized in Table 5, to obtain the PLO assessment results. The original data were measured on a 1 to 5 Likert scale, 5 being the best / most agreeable.

In the ITB Alumni Users Survey, supervisors of alumni in their occupations provide perceptive feedback on competency items that are identical to the Alumni Survey summarized in Table 5 (and also in Table 2 in the context of PEO assessment). Compared to the Alumni Survey, however, the Alumni User Survey measures two dimensions for each competency item: (1) the importance of each competency for the particular alumni's occupation, and (2) the user's satisfaction with the level of competence of the particular alumni. The original survey data collected by ITB were measured on a 1 to 5 Likert scale, 5 being the best / most agreeable. Analogous to the Alumni Survey, the Alumni User Survey results are mapped to the seven PLOs. For each PLO, scores of the different dimensions are averaged.

Results of direct and indirect assessments of PLOs are compiled in Figure 3. All assessment scoring data are normalized to a 0-100% scale. Key observations from Figure 3 are as follows:

- Direct assessments of PLO #1 indicate a lower score than its indirect assessment. Although this decrease in coursework-based assessment results may be related to the emergency online learning implemented during the COVID-19 pandemic, it nevertheless identifies the need for a sufficient proportion of coursework that may enable better learning of mathematics and basic sciences.
- Direct assessments of PLO #1 through #5 exhibit higher attainment levels than indirect assessments, suggesting an effective learning experience of these outcomes. While scoring lower than the direct assessment, the indirect assessments of these outcomes are rather tightly clustered in the 75-85% range. This suggests that graduates and their employers regard these outcomes as relevant for the graduates' professions.
- Direct assessments of PLO #6 also indicate a high level of attainment. However, approximately 70% of the User Survey assessment score for PLO #6 is the lowest of all PLOs in Figure 3. This suggests that course learning outcomes and performance indicators associated with PLO #6 must be revised to improve their relevance to the industry.
- Indirect assessments of PLO #7 exhibit a high satisfaction and relevance of this outcome to the graduates' and their employers' needs, with assessment scores tightly clustered in the 82-87% range. However, the direct assessment score for this PLO is slightly lower at 79%, indicating a potential to further nurture lifelong learning skills and attitudes through the new curriculum.

Overall, the assessment results indicate satisfactory PLO attainment except for PLO #1. Considering the inevitable reduction of learning quality during the COVID-19 pandemic, our graduates and their employers perceive all PLOs as relevant for professional practice. As a further confirmation of the relevance of the current PLO, the Program Advisory Board has also expressed their support and that essentially, no change in PLO is necessary for the Curriculum 2024. The only revision implemented in Curriculum 2024 is the deletion of Sub-PLO #7-2 (Utilize personal computers for engineering calculations, using programming language or spreadsheets), which was deemed rather trivial for today's basic computing skills of ITB undergraduate students in general.

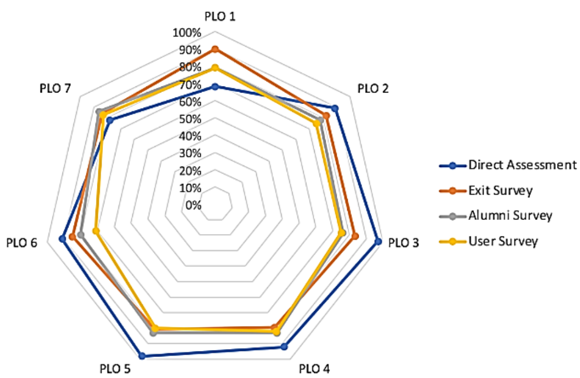

Fig. 3: Chemical Engineering UG Program Learning Outcomes assessment results using four instruments: direct assessment from classwork, Exit Survey by the Program Quality Assurance Unit, Alumni Survey, and Alumni User Survey by ITB Student Directorate Office. The graph shown is a representative figure from data collected in 2021.

CONCLUSIONS

ITB's Chemical Engineering UG Program has conducted exhaustive assessments of its Program Educational Objectives and Program Learning Outcomes to develop Curriculum 2024. These assessments included direct, coursework-based, and indirect assessments encompassing exit, alumni, and employer surveys. The Program Advisory Board has also weighed in on finalizing PEO and PLO for Curriculum 2024.

Mapping PEO items to results from the Alumni User Survey in 2023 and feedback from the Advisory Board have confirmed PEO's relevance, which was last updated in 2021. Thus, the PEO is maintained for the Curriculum 2024.

Likewise, direct and indirect assessment results for PLO indicate the generally satisfactory level of attainment by graduates (considering the impact of the recent COVID-19 pandemic) and their relevance to the needs of the industry and profession. Therefore, the Curriculum 2019 PLOs generally remain intact except of for deleting one Sub-PLO that was deemed too trivial for Curriculum 2024.

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