

Educating the Sustainable Engineering Technologists: Aligning Technical Training with Evolving Consumer Expectations in the Built Environment

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Abstract— Achieving sustainability in the built environment begins with how we educate future engineers. As the construction industry moves toward greener, more resilient practices, engineering technology education must also evolve—shifting from passive knowledge delivery to experiential, industry-connected learning that builds both technical skills and environmental awareness. In the Soil Mechanics & Foundations course for second-year Civil Engineering Technology students, this shift was realized through an industry-based Project-Based Learning (PBL) initiative. To overcome the challenges of traditional site visits, students participated in a 14-week, real-world simulation themed “From the Industry, to the Industry.” Working in teams, and mentored by Industrial Advisors, students engaged in a structured process: identifying ground failure mechanisms, developing sustainable geotechnical solutions, and planning for implementation. This approach connected classroom theory with green engineering practices, enhancing both relevance and critical thinking. The project addressed four Course Learning Outcomes (CLOs): Applying geotechnical fundamentals, integrating sustainability considerations, using modern engineering tools, and presenting practical implementation strategies. Deliverables included a technical portfolio, a short paper, and a 3-minute technical video. Assessment was triangulated using project outputs and student reflections, mapped to the Sydney Knowledge Profile across cognitive, psychomotor, and affective domains. Results showed strong achievement in sustainability-focused CLOs, though gaps in analytical reasoning suggest a need for deeper integration of theory and environmental problem-solving.

Keywords: Higher education, soil mechanics, problem-based learning, industrial exposure.



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INTRODUCTION

The incorporation of an Industry-based Problem-based Learning (PBL) project in the core discipline course of Soil Mechanics & Foundations enhanced the learning relevance and engagement for students to facilitate deep learning. PBL is free of conventional spoon-feeding approach in the classroom, utilising original, complex, real field problems as the basis for investigation and problem-solving. Associated with technical solutions underlain by the course contents, including lecture and laboratory works, the authentic problems usually reside beyond the educational realm and over-reaching actual industrial applications (Strobel, Tumasjan, Spörrle & Welp, 2013). As the issues are derived from real challenges encountered by various stakeholders of the related sector, from designers, specialists, contractors to local community, students are given a more tangible, realistic context for effective learning. A unique characteristic of industry problems is the

seeming randomness and myriad possibilities, absent of neither clear-cut solution paths nor single, absolute correct answers (Taylor & Govender, 2017). The unstructured and open-ended nature of the problems simultaneously reflect professional challenges awaiting students in the field, engaging them in a rigorous learning process via critical and creative thinking, iterative problem analysis and decision-making with due considerations of the consequences (Kim & Alvarez, 2025). As pointed out by Aarons and Naik (2024), students are encouraged to draw on and apply knowledge and skills from various sub-disciplines to formulate comprehensive solutions in an innovative, targeted manner. This encompasses considerations beyond the engineering technology fields of study, including the related socio-economy and environment aspects. The outcome-oriented approach produces tangible results too, such as product and conceptual model, among others (Graham & Tait, 2024), developing students' sense of responsibility as well as

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accountability in their professional endeavours.

It follows that introducing the industry in classrooms through the incorporation of industry-based PBL brings forth substantial educational advantages absent in other less proactive approaches. The practice may require extra preparation and rigorous execution plan, but the positive impact on students' learning clearly makes the effort a worthwhile one.

INDUSTRY IN CLASSROOM

Introduction of industry's involvement in class projects enable students to follow through the problem-solving procedure in a collaborative work environment, simulating the real-world playing field, where the industry's contribution come in the forms of initial problem framework, prompt feedbacks, practitioner's insights and mentoring (Figure 1). Via the industry-based project, students are actively exposed to the current industry's needs and trends, shaping them to be more prepared for employment with far sight career pathway planning (Narayan & Sarahan, 2024). Students are also driven towards enhanced engagement with intrinsic motivation for crafting solutions of real-world implications (Zakaria, Azri & Azmi, 2024) creating an immersive learning experience compared to conventional passive methods (Rahman & Hossain, 2024). On a separate note, industrial involvement in the classroom encourages students to take into account the ethical implications of their work and addressing the issues that affect the wider society, such as fair practices, public safety and societal (Felton & Lambert, 2020; Patrick et al., 2008). Moreover, the approach encourages students to explore beyond the technical solutions for contribution towards the greater system via values-driven decision-making (Moreira et al., 2024; Tabala, Munene, Kagaari, Mafabi, & Kyogabiirwe, 2024). As suggested by Ferdman and Ratti (2024), it is imperative that

students are guided to extend their technical judgement and reasoning from the individual, problem-specific level to that of the societal responsibilities. Similarly, Mitra and Raskin (2023) emphasized on students' ability to weigh and balance peripheral sustainable development goals with technical objectives of their future professional undertakings.

In line with the expanded horizons of modern workforce with enriched diversity, in terms of ethnicity, nationality and areas of expertise, soft skills like communication, creativity and innovation, adaptability and flexibility are of paramount importance (Youngerman & Culver, 2019). PBL projects provide the platform for students to build independence and self- confidence, while working collaboratively with the other team members (Chua & Lee, 2024). The ability to seek information and learn independently is also a useful skill for students to navigate the future workplace and challenges by adopting continuous learning (Tabala et al., 224). Indeed, Blossom (2024) found independent learners to be able to consciously identify their respective specific interests, followed by proactive actions to customize their learning experience towards the designated goal. This effectively expedites learning of the specific areas to fill in the knowledge or skill gap, as highlighted by Ramao et al. (2024) and Popli and Singh (2024).

The above discourse clearly indicates the urgency to embed industry-based elements for the advancement of students' learning, especially those in the dynamic technical and engineering technology fields of study. An industry-based investigative project was assigned to 98 year 2 students undertaking the 4-year bachelor's degree programme in Civil Engineering Technology, for the core disciplinary course of Soil Mechanics & Foundations. Further details of the fondly termed "SOILproject" are presented in the next section.

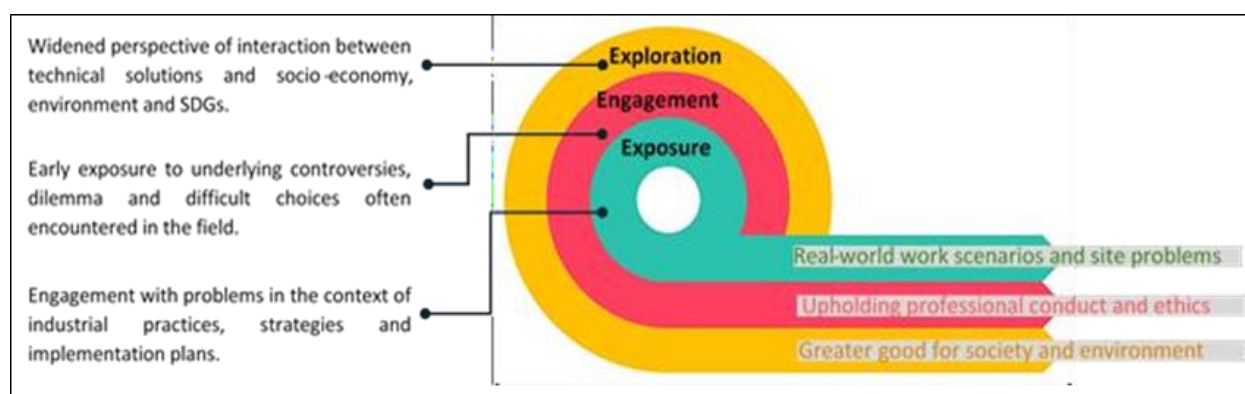


Figure 1. Industry in classroom: Positive ripple-effect for students' learning

THE INDUSTRY-BASED PBL PROJECT

What was done: The Project Brief?

The SOIL project was designed for students to develop solutions to a real-world geotechnical problem given by the Industrial Advisor, who also played the role of mentor throughout the 14-week Project duration.

Established advantages such as fostering deep learning through provision of technical guidance, contextual insights and formative feedback of the mentoring scheme can be found in a number of past works (Chua

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& Lee, 2024; Gomez, Clarke & Bui, 2023; Aziz & Ali, 2023). Working in groups of 4, students kicked off the Project by identifying a site with geotechnical failures, and examining the cause-effect mechanisms for potential solutions. Next, each group explored options to resolve the root cause of the problem with specific site-suitability and practicality, including resources availability, site accessibility and sustainable development concerns. Finally, a holistic implementation plan with all-inclusive considerations, technical and non-technical, was proposed. Throughout the Project period, students had at least 4 consultation sessions with the lecturer to ensure adherence to the requirements per evaluation rubrics.

Submission included: (1) a 3-minute technical video, giving a concise and precise narration of the Project respectively, i.e. informative, comprehensive, interesting and eye-catching to engage with the viewers; (2) a Project Portfolio which was essentially a compilation of the Project development in an organized arrangement of references, minutes of meeting, sketches, idea sheets and technical drafts; (3) a technical paper with the outline given per Figure 2. It is apparent that details of technical write-up were tied up with the Evaluation Rubrics, with notes reminding students the key elements for inclusion in the respective sub-topic of the paper. These elements are further discussed in the ensuring section. The guidance helped ensure students remain on track while progressing through the Project,

simultaneously cultivating time management skills in meeting the milestone deadlines (Nguyen, Pham & Ali, 2023; Jones & Alam, 2023).

As shown in Figure 3, site selection with advice from Industrial Advisor was carried out in the first 2 weeks of the semester, followed by an intensive literature review, background study and site visits where necessary up till week 5, as indicated by the second milestone of idea formulation based on the failure mechanisms determined. Next, students refined the idea with regard to technical feasibility and stakeholders' interests, to propose a solution with balanced fulfillment of the needs and purposes of all involved. The close guidance by the Industrial Advisor ensured optimised exposure to the practical side of civil engineering technology applications, as propounded by Kumar & West (2024) as well as Li & Patel (2024) particularly expedient for engineering-based courses. This was followed by a couple of weeks for further refinement and finalisation of the solution, incorporating nature-centric and sustainable development components executional via a detailed field implementation work plan. This phase of work involved the technical video creation as well as technical paper writing. Coming into week 12-14, the Project was presented to panelists for evaluation, where the comments and inputs were taken into account for the final corrections. The final submission was due in week 14, so as not to encroach on the Revision Week (week 15) leading to the Final Examinations from week 16-18.



Figure 2. Preparatory guidelines for the technical paper

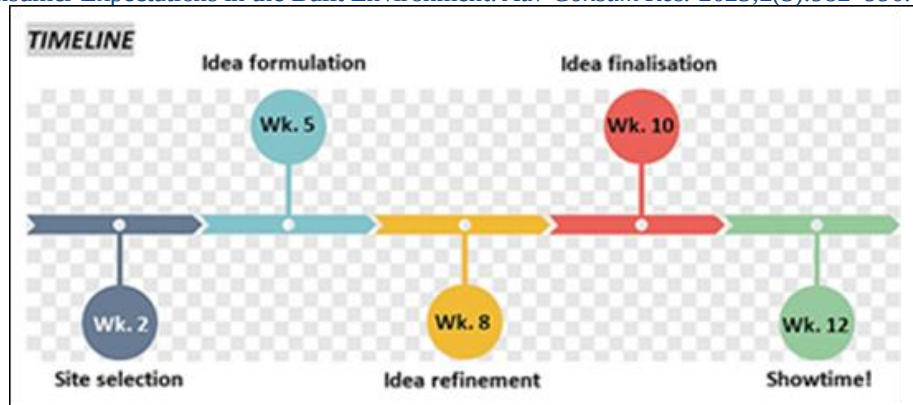


Figure 3. Timeline and milestones for the project

What was learned: The Course Learning Outcomes (CLOs)

The Project was mapped to all 4 CLOs for the course, encompassing the 2nd, 5th, 7th and 10th. Programme Outcomes (POs) in the areas of problem analysis (CLO1-PO2), tool usage (CLO 3- PO5), environment and sustainable development (CLO2- PO7) and communications (CLO4- PO10). The 4 CLOs are as follows:

- CLO1 -Analyze the application of technical and design fundamentals of soil mechanics and foundations with reference to relevant standards, principles and current technology. (PO2 Problem Analysis; SK3, SK4, SP1, SP3, SP4)
- CLO2 -Relate geotechnical solutions with environmental concerns and sustainable development in the context of effective field implementation. (PO7 Environment and Sustainability; SK3, SK7, SP1, SP2, SP6)
- CLO3 -Organize geotechnical as well as geo-environmental laboratory and in-situ measurements with practical considerations. (PO5 Modern Tool Usage; SK3, SK4, SK6, SP1, SP3, SP4)
- CLO4 - Demonstrate to all levels of experts and laymen alike on the fundamentals of geotechnical and geo-environmental engineering with emphasis on field implementation and technical problem-solving. (PO10 Communications; TA2, TA3, TA4)

Note that the parenthesis for each CLO statement indicates the corresponding Sydney Knowledge Profile elements, i.e. SK- knowledge and attributes, SP- broadly-defined engineering problems and TA- broadly-defined engineering activities. The POs were aligned with those prescribed by the Engineering Technology Accreditation Council (2020) where the Course contributed to the students' cumulative growth in the respective targeted outcomes. It follows that CLO1- PO2 emphasizes the cognitive domain of analytical skills using specialized technical knowledge, CLO2- PO7 focuses on the acuity

towards environmental wellbeing and sustainable development, CLO3- PO5 highlights the adoption of relevant tools for the engineering works, and CLO4-PO10 is dedicated to effective communications on engineering activities to both the professional and general audience or readers. Human participation and positive behavioral approaches foster holistic student growth to meet industry's demands (Rafique, Jaafar & Zafar, 2024) as reinforced by the CLOs covering cognitive, psychomotor and affective domains. This integrated framework enhances engagement through active listening, inquiry, and practical application, effectively preparing Civil Engineering Technologists for real-world professional challenges.

Accordingly, the total marks of 45% were shared across the CLOs per Figure 4, starting with 4 progress reports, 1 technical paper and video recording respectively, as well as the Project portfolio. Referring to Figure 4, it is apparent that students were also subjected to a wide range of soft skills cultivation and development by working on the Project. The group setting itself had the students working in groups of 4 where teamworking skills were honed, coupled with rotating leadership roles in managing the Project. Irrespective of the mentoring and guidance provided by both Industrial Advisor and lecturers, students learned to conduct independent, self-directed learning, especially in the quest for the most effective solutions. Needless to say, the Project propelled towards research skills too, including literature review, critical thinking and reporting in written and verbal formats. Of course, it also served as a platform for understanding the relationship between theories and practices, exemplified by the investigation for a real-world problem to the derivation of an all-encompassing conceptual solution to meet the stakeholders' concerns while complying to the rules and regulations with minimal disruption to the existing environment.

• Progress (4x)	CLO 1&4	15 %
• Technical Paper	CLO 2, 3 & 4	10 %
• 3-minute Technical Video	CLO 2, 3 & 4	10 %
• Project Portfolio	CLO 2, 3 & 4	10 %
		TOTAL 45 %

Figure 4. Breakdown of the marks for project assessment

What was evaluated: The Sydney Knowledge Profile

The evaluation process can be simply divided into 3 stages, namely the beginning, the progress and the finalisation of the Project. Evaluation Rubrics were carefully crafted to reflect the intended learning outcomes, knowledge and attributes, as well as the aptitude to address specific broadly-defined engineering problems and activities. Table 1 gives an example of the rubric structure, with clearly defined learning outcomes and knowledge profile tracking the sequential development of the Project. On a Likert scale of 1 to 5 in ascending mastery level and well-marked boundaries between each level of attainment, the rubrics enabled evaluation to be carried out with objectivity, i.e. free from bias, ambiguity and uncertainties among the panelists. Students were also regularly reminded to use the rubrics as a guideline for their work progress, with the aim (1) to avoid delays due to unnecessary digression or detours, (2) to focus on the primary components stipulated as

evaluation criteria, and (3) to explore further on the more challenging components via reference to past records, consultations and discourse with Industrial Advisor.

Stage 1 of the Project was mapped to CLO1 and embedded with SK3 (Table 1): A systematic, theory-based formulation of engineering fundamentals required in the Geotechnics sub-discipline, SK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the Geotechnics sub-discipline; SP1: Depth of knowledge required. The tasks involved preliminary studies, information gathering and review of the geotechnical failure mechanisms for potential feasible solutions. This was a crucial stage of the Project, for the site selection and related details were determined at this stage, laying the groundworks for the geotechnical failure investigation that ensued.

Table 1. Example of Assessment rubric: Stage – Work Initiation

Item	Description	Marks (Weak ➡ Excellent)				
Site Story: The beginning ...CLO1-SP1-SK3&4						
1	Compilation and presentation of site information including photos, maps, plans, layouts, sketches, etc.	1	2	3	4	5
2	Identification of geotechnical problems from the information gathered.	1	2	3	4	5
3	Examination of the causes of the geotechnical problems identified in item (2).	1	2	3	4	5
4	Suggestion of potential solutions to the causes examined in item (3).	1	2	3	4	5
5	Includes relevant references to support items (1) to (4)	1	2	3	4	5

Stage 2 of the Project evaluation consisted of 2 parts, capturing students' progress and growth per the milestones given. Part 1 related CLO1 with SK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the Geotechnics sub-discipline; SP4: Familiarity with related issues and SP6: Extent of stakeholders' involvement and level of conflicting requirements. Part 2 of the second stage revolved around CLO4 and TA4: Have reasonably predictable consequences within the local and global context. The causes of failure identified in Stage 1 were further examined, to determine the actual cause-effect mechanisms for precise solution formulation. Students also began to widen their investigation into peripheral factors that could hinder the proposed solution, including the stakeholders, environmental restrictions and logistical concerns. This was an impactful exercise to raise students' awareness of the consequences of

engineering solutions to the living and non-living spheres around the Project, which took them beyond the boundaries of textbooks and lectures. The main outputs of Stage 2 were the technical solution, resolution of conflicting stakeholders' interests, and mitigation of environmental harm caused by the solution itself.

For the subsequent discourse, note that statements for the SK, SP and TA already mentioned above will not be repeated. Referring to the 4-part Final evaluation upon completion of the Project, Part 1 consisted of the evaluation components for the submitted work, namely the technical paper and video, and the Project Portfolio. In Part 2, students were required to demonstrate responsible and accountable practices with respect to sustainable development aspirations, i.e. CLO2 incorporating SK3: A systematic, theory-based formulation of engineering fundamentals required in the

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Geotechnics sub-discipline, SK5: Knowledge that supports engineering design/ solutions using the technologies of the Geotechnical practice area, and SK7: Comprehension of the role of technology in society and identified issues in applying the geotechnical engineering solution, while observing related ethics and impacts from the perspectives of socio-economy, environment and sustainability. Compliance with these components would suggest that students were able to integrate their technical knowhow with existing and emerging surrounding factors.

Part 3 aims to evaluate students' ability to adopt suitable tools and technology in implementing the proposed solution, as stipulated in CLO3. This involved SP1- SK3 and SK4 to design the solution based on related geotechnical fundamentals and specialist knowledge, SP3 to apply well-proven analysis techniques, SP1- SK6 to utilize relevant knowledge of geo- engineering technologies, and SP7 to integrate the solution within the greater, more complex engineering problem. In this part, students would detail out a comprehensive implementation plan that caters for the limitations with innovative approaches and calculated risk prediction. Wrapping up the evaluation is Part 4, which directed students' attention to CLO4 embedded with TA2 in resolving conflicting technical and non-technical issues arising from the proposed solution, and TA3 in adapting available resources to the challenges on site creatively, via modification, combination and innovation.

It is noteworthy that CLO4 carries with it an undertone for specific communication skills or approaches to be adopted in different scenarios of engineering activities, enlightening an audience of experts and layman alike, especially in civil engineering works which often involve a complicated network of stakeholders. The selected engineering activities depicted by TA2 and TA3 were indeed intertwined: Interaction of conflicting interests among the various parties affected by the proposed solution (TA2), requiring a flexible and adaptive strategic plan to execute the solution to minimize grievances, losses or disputes, and to maximize efficiency, collaboration and satisfaction of all needs (TA3).

THE TRIANGULATION ANALYSIS

Evaluated performance

Figure 5 is the summary plot of students' performance in the Project, as categorized per the respective CLOs. With an average attainment of 70%, all learning outcomes were fulfilled by meeting the target of 50% attainment level. The results indicated students' much improved knowledge on the impact of technical solutions to preservation of the environment (CLO2), and sharpened acuity in making selection of tools and technology for a given problem (CLO3). On the other hand, their analytical prowess in resolving technical problems (CLO1) appeared to be slightly lower at 67%. Similarly too for CLO4 pertaining to element of communication in the context of broadly-defined engineering activities (CLO4). Recording 48% and 34% positive differences

for CLOs 2 & 3 (attained 74%) and CLOs 1 & 4 (attained 67%) respectively with the target level, it is deduced that students probably faced an uphill battle in relating and applying knowledge and skills learned in the practical context. It would also appear that students struggled a little to deliver the message when it came to moderating conflicts and issues arising from the proposed solution, TA2 and TA3. Clearly CLO1 and CLO4 were closely related to the central theme of the Project, i.e. critical examination of the geotechnical failure, formulation of feasible solution options, followed by addressing the often contradicting needs of the stakeholders. As real as real-world scenarios are to be expected, it nevertheless gave students some insights to the challenges in their future career path.

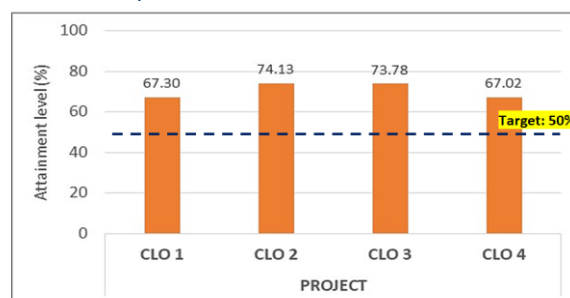


Figure 5. Evaluated performance of students per CLO attainment

Students' Perception

Students' responses to the semester-end survey are compiled in Figures 6-9, as aligned with the respective CLOs with 2 elements each assigned every CLO, e.g. CLO1 was further split to 1a and 1b. Following is the discourse on their self-review in terms of the learning outcome attainment levels respectively.

CLO1. Referring to Figure 6, almost half the students regarded themselves as 'good' to 'excellent' in analysing the technical fundamentals of Geotechnics with reference to relevant standards and principles, though a minute 3% somehow found the endeavour daunting (1a). In examining the design fundamentals per current or advanced technology (1b), majority of the students ranked themselves 'good' for having acquired the skills well (48%), while 44% showed more confidence in the 'excellent' category, and 8% regarded their performance to be 'satisfactory'. Considering the gap between theory and practice, this observation corroborates with the grading for CLO1 in Figure 5: It is understandable that students would face some hurdles to fill in the gap in this first encounter with actual field conditions and limitations.

CLO2. Looking at Figure 7, 2a examines students' ability to relate geotechnical solutions with environmental concerns for effective field implementation, while 2b gauges their judgement in adopting suitable geo-technology in field application for

sustainable development. Compatible with the performance for CLO2 in Figure 5, both elements came

out strong with >50% of the students perceived themselves to have successfully acquired the necessary insights to propose feasible technical solutions without compromising on environmental wellbeing, public safety and sustainable development practices. Of course, a minority of 7.5% rated themselves lowly, most probably due to limited independent engagement with relevant resources to enhance their understanding, and inadequate active participation in their respective group discourse.

CLO3. The self-review for CLO3 attainment is compiled in Figure 8:3a depicts the ability to organize geotechnical laboratory and field measurements by taking into account the practical implications, and 3b focuses on the arrangement of geo-environmental laboratory and in-situ measurements with consideration of field conditions. Both elements recorded similar results, where over 90% of responses were in the range of ‘good’ to ‘excellent’, suggesting students’ confidence to weigh and select the most appropriate technical approaches in the face of

common geotechnical problems on site (see Figure 5 for CLO3 too). This is an encouraging finding indeed, considering that engineering technology is very much about troubleshooting practical problems based on a firm grasp of the theoretically derived mechanisms.

CLO4. Figure 9 illustrates the survey response on (4a) the ability of students to demonstrate to all levels of experts on the basics of geotechnical and geo-environmental engineering with emphasis on field implementation and technical problem-solving, and (4b) the aptitude to explain to non-experts and the public about geotechnical or geo-environmental engineering issues, cause-and-effect as well as solutions. Closely related to CLO1, with emphasis on students’ mastery of the underpinning principles and theories for precise analytical or practical applications, this learning outcome requires profound understanding of the technical subject matter before it can be simplified or adapted for dissemination to the public. Therefore the rather esteemed self-rating shown here may be misleading if not inaccurate.

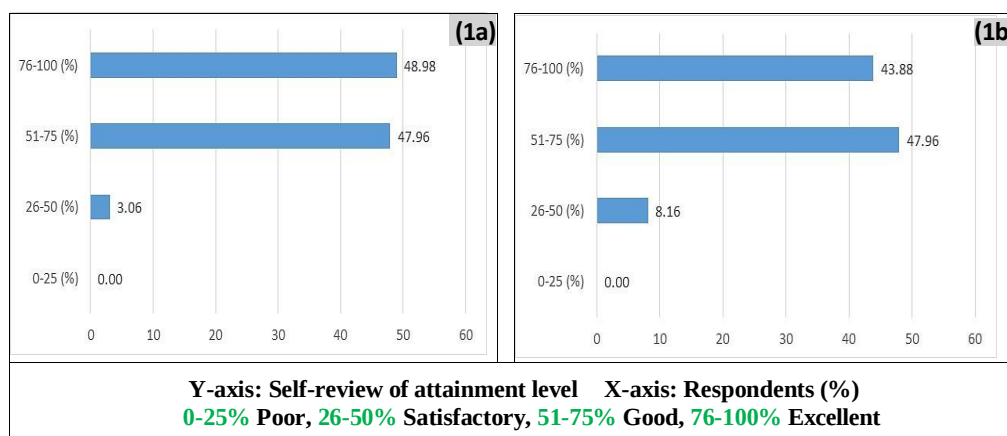


Figure 6. Self-reviewed attainment of CLO1: Problem analysis

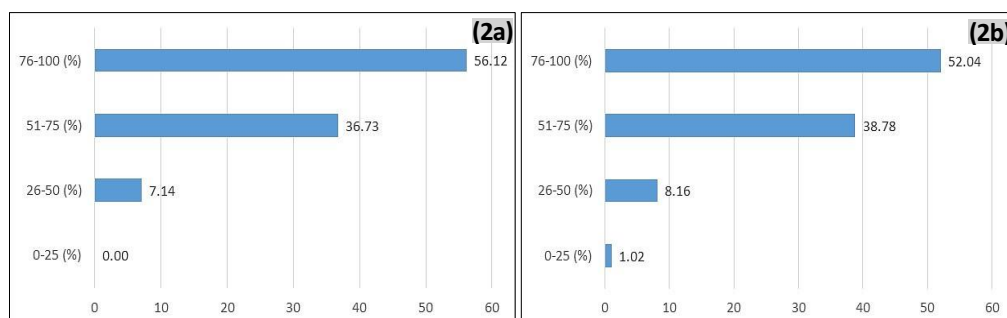


Figure 7. Self-reviewed attainment of CLO2

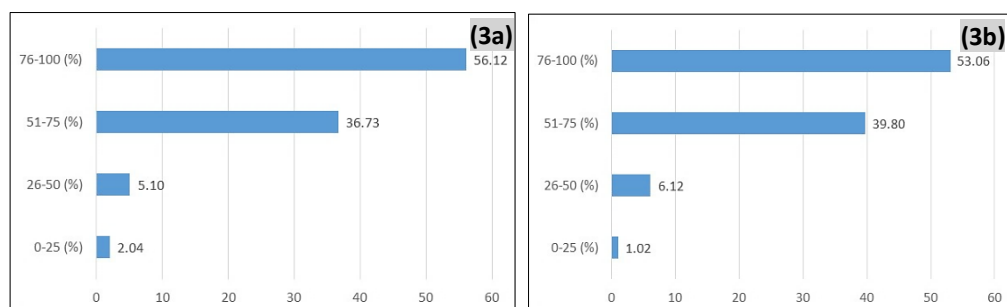


Figure 8. Self-reviewed attainment of CLO3

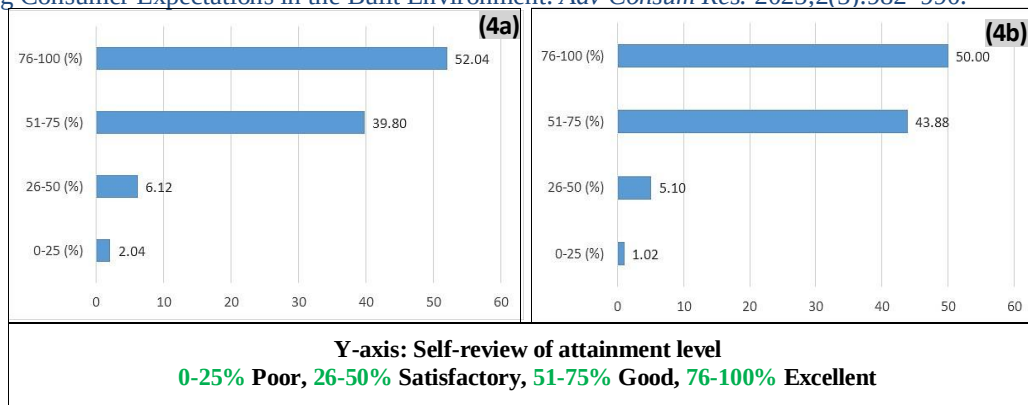


Figure 9. Self-reviewed attainment of CLO4

Data Comparison and Integration

Figure 10 is the combined plots for students' performance per actual evaluation (MARKS) and self-review (SURVEY). Note that self-perceived performance consistently outdid that of evaluation for every CLO in the 'excellent' category, i.e. ranging from 19% (CLO2) to 60% (CLO1) discrepancy between the 2 measurements. The over-rated performance by students' perception could be caused by the notion of not knowing what they do not know, hence leading to an inflated sense of self-assurance and unsubstantiated confidence. Truth is, as evidenced by the 'good' category in Figure 10 where the connecting plot for MARKS lies way above that of SURVEY, implying that most students fell under this category and not the higher tier of excellence. The

mismatch between SURVEY and MARKS is particularly jarring for CLO1 and CLO4, which explains the discordance highlighted in the discourse for Figure 9. Therefore it can be concluded that while students may have over-rated their performance, the fact remains that they did well overall with 56-77% achieving the 'good' category, on top of the 19-44% who made it to the top tier of 'excellence'. This leads to a most heartening actual performance of an average of 32% in the 'excellent' bracket and 65% in the 'good' category across all the CLOs. In a simulated distribution chart, it would have produced a right-skewed bell curve of promising peak in the 'good' region.

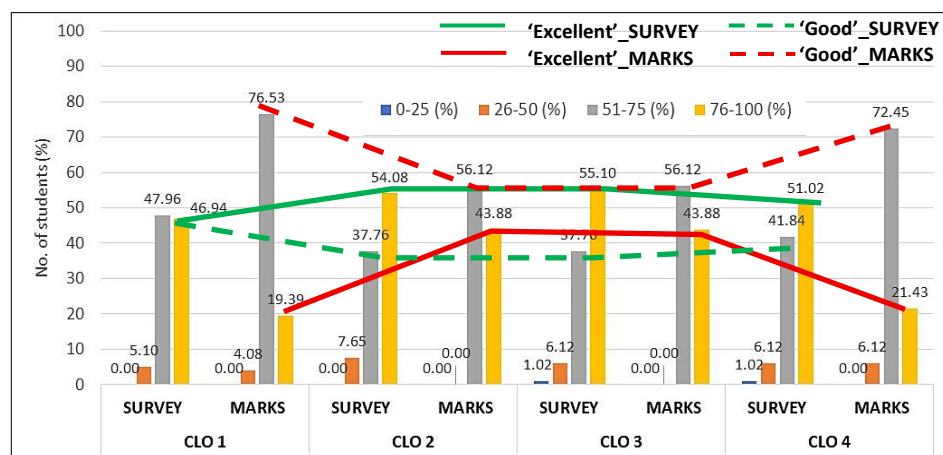


Figure 10. Cross-correlation between actual performance (MARKS) and self-perception (SURVEY)

CONCLUSIONS

The triangulation approach adopted to review students' actual and perceived performance in the industry-based PBL project, nicknamed SOIL project in conjunction with course of Soil Mechanics & Foundations, revealed the otherwise obscure learning outcome of the students. Admittedly barely one-third of the class achieved 'excellent' performance, especially in areas that require theoretical reasoning and critical analysis (CLOs 1 & 4), 65% of the students did make the cut of 'good' performance overall. These insights could serve as useful inputs for review of the course contents, structure and delivery methods, initiating the continuous quality

improvement cycle to customize the course in parallel with industrial expectations yet conforming to academic rigour not always viable due to various constraints, especially time and resources. Notwithstanding the apparent limitations, industry-based PBL project proves to be an effective engagement to facilitate deep learning among students, while broadening their industrial exposure and societal conscience for better preparedness entering the job market upon graduation.

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REFERENCES

1. Aarons, J. and Naik, R. (2024) Integrative Engineering Pedagogy. *Journal of Engineering Education Research*, 41(2): 93–112.
2. Aziz, M. A. Ali, and S. (2023) Mentorship and Industry Integration in Undergraduate Engineering Project-Based Learning. *ASEE Annual Conference Proceedings*.
3. BEM-ETAC, Engineering Technology Programme Accreditation Standard (2020).
4. Blossom, K. C. (2024, March 7). Why self-directed learning is still vital in the workplace. <https://www.blossom-kc.com/blog/why-self-directed-learning-is-still-vital-in-the-workplace/>
5. Chua, W. L. and Lee, C. K. (2024) Cross-Disciplinary Learning in Engineering Capstone Projects. *International Journal of STEM Education*, 11(1): 15.
6. Felton, P. and Lambert, L. M. (2020) Relationship-Rich Education: How Human Connections Drive Success in College. United States of America: Johns Hopkins University Press.
7. Ferdman A. and Ratti, E. (2024) What Do We Teach to Engineering Students: Embedded Ethics, Morality and Politics. *Sci Eng Ethics*, 30(1):7.
8. Gomez, R., Clarke, J. and Bui, T. (2023) Integrating Industry Challenges into PBL: Enhancing Authenticity and Mentoring in Civil Engineering Education. *International Journal of Engineering Education*, 39(2): 174–187.
9. Graham, P. and Tait, R. (2024) Practice-Based Learning in Civil Engineering. *Journal of Experiential Learning in Engineering*, 13(3): 201–217.
10. Jones, A. and Alam, M. (2023) Mentorship in STEM Capstone Projects: Impacts on Student Time Management and Outcome Quality. *Journal of Experiential Learning in Higher Education*, 18(1), 35–48.
11. Kim, Y. and Alvarez, S. (2025) Cognitive Load and Multidisciplinary Engineering Education. *Advances in Engineering Education*, 18(1): 22–40.
12. Kumar, D. and West, C. (2024) Sustainability Integration in Capstone Engineering Projects: Role of Industry Mentors. *Journal of Environmental Engineering Education*, 19(2): 66–78.
13. Li, X. and Patel, M. (2024) Industry-aligned Capstone Projects: Enhancing Student Engagement through Feasibility-driven Design. *International Journal of STEM Education*, 11(2): 88–101.
14. Mitra, S. and Raskin, J. P. (2023) The Paradox of Industrial Involvement in Engineering Higher Education. 2023 IEEE Frontiers in Education Conference (FIE), 1-6.
15. Narayan, A. and Saharan, A. (2024) Reshaping Engineering Education: Fostering Critical Thinking through Open-Ended Problems in the Era of Generative AI. 2024 ASEE Annual Conference & Exposition.
16. Moreira, A., Leifler, O., Betz, S., Brooks, I., Capilla, R., Coroama, V. C., Duboc, L., Fernandes, J. P., Haldal, R., Lago, P., Nguyen, N., Oyediji, S., Penzenstadler, B., Peters, A. K., Porras, J. and Venters, C. C. (2024) A Road Less Travelled and Beyond: Towards a Roadmap for Integrating Sustainability into Computing Education. *arXiv preprint*. 2406:18945.
17. Nguyen, T., Pham, H. and Ali, S. (2023) Developing Professional Skills through Guided Industry-Based Learning in Engineering Education. *International Journal of Work-Integrated Learning*, 24(2): 101–115.
18. Patrick, C. J., Peach, D., Pocknee, C., Webb, F., Fletcher M. and Pretto, G. (2008) The WIL (Work Integrated Learning) Report.
19. Popli, N.K. and Singh, R. P. (2024) Enhancing Academic Outcomes through Industry Collaboration: Our Experience with Integrating Real-World Projects into Engineering Courses. *Discover Education*, 3(1): 217.
20. Rafique, M., Jaafar, M. and Zafar, A. (2024) Unveiling Abusive Supervision in Projects: Evidence and Future Research Directions. *Malaysian Construction Research Journal*, 42(1): 27-57.
21. Rahman, M. S. and Hossain, A. R. M. T. (2024) The Effects of Problem-based Learning on Students' Learning Engagement in Bangladesh College Education System. *Journal of Social Science*, 5(1).
22. Romao, L., Kalinowski, M., Barbosa, C., Alex Araújo, A., Barbosa, S. D. J. and Lopes, H. (2024) Agile Minds, Innovative Solutions and Industry-Academia Collaboration: Lean R&D Meets Problem-Based Learning in Software Engineering Education. *arXiv preprint*, 2407: 15982.
23. Strobel, M., Tumasjan, A., Spörrle, M. and Welp, I. M. (2013) The Future Starts Today, Not Tomorrow: How Future Focus Promotes Organizational Citizenship Behaviors. *Human Relations*, 66(6): 829–856.
24. Tabala, A., Munene, J., Kagaari, J., Mafabi, S. and Kyogabiirwe, J. (2024) Does Individual Adaptability Mediate the Relationship Between Personal Initiative and Psychological Well-Being: Evidence From Uganda's Small Enterprises. *Journal of Humanities and Applied*

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25. Taylor, S. and Govender, C. M. (2017) Increasing Employability By Implementing A Work-Integrated Learning Partnership Model In South Africa—A Student Perspective. *Africa Education Review*, 14(1): 105–119.
26. Youngerman, E. and Culver, K. (2019) Problem-Based Learning (PBL): Real-World Applications to Foster (Inter) Disciplinary Learning and Integration. *New Directions for Higher Education*, 188: 23-32.
27. Zakaria, N. H., Al-Azri, N. and Azmi, M. (2024) Incorporating an Open-Ended Project to Address Complexity in Undergraduate Engineering Labs. *Proceedings of the ASEE Annual Conference*.