CO-LOCATION LABS FOR AUTHENTIC LEARNING: EXPERIENCES FROM SINGAPORE POLYTECHNIC'S ENGINEERING CLUSTER

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ABSTRACT

The rapid evolution of technology presents constant challenges for Institutes of Higher Learning (IHLs) in maintaining curriculum relevance whilst ensuring graduates possess industry-ready competencies. This paper examines how Co-location labs (Co-labs) within Singapore Polytechnic (SP)'s Engineering Cluster address these challenges through systematic industry-academia collaboration, exploring how students achieve authentic learning within Engineering Learning Workspaces under the CDIO framework. The paper first provides a literature review on different approaches to industry-academia collaboration, namely internships and Co-location arrangements, discussing their relative merits in affording real-world learning experiences. This work further examines Co-lab implementation within SP's Engineering Cluster, which comprises the Schools of Electrical and Electronic Engineering (EEE) and Mechanical and Aeronautical Engineering (MAE). Through the Cluster Industry Engagement Centre (CIEC), strategic partnerships have established physical industry presence on campus featuring Industry 4.0 applications, 5G and AIoT systems, Smart Energy Technologies, and Advanced Manufacturing solutions that emphasize hands-on learning and collaborative environments. Survey results based on stakeholders' feedback and focus group discussion are shared to examine experiences with Co-location learning environments. The study investigates how these engineering workspaces enhance students' learning outcomes, develop their skill attributes, and improve their industry readiness, whilst several implementation challenges are identified and elaborated upon. Findings demonstrate that Co-labs provide a means to advocate CDIO Standards 6 and 7 through industry-integrated environments supporting concurrent skill development. This approach enhances faculty competence (Standard 9) through direct industry exposure and collaborative opportunities with professional practitioners. The paper concludes with reflections on Co-labs as effective mechanisms for supporting authentic learning in IHLs. Key success factors are identified, and strategies for overcoming implementation challenges are proposed using guidance from the CDIO Framework, providing a roadmap for other institutions seeking to implement similar initiatives in engineering education.

KEYWORDS

Co-location Lab, Engineering Education, Academia and Industry Partnership, CDIO Standards 1-3, 6, 7 and 9.

INTRODUCTION

The accelerated evolution of emerging technologies is fundamentally transforming the industrial landscape (Gartner, 2024), presenting unprecedented challenges for tertiary education institutions globally. The imperative to maintain curriculum relevance amid rapid technological advancement has emerged as a critical concern for educational institutions. Recent data indicates a significant disruption in workforce skills, with 44% of workers' competencies projected to be disrupted within a five-year timeframe, and approximately 60% of the workforce requiring reskilling by 2027 (World Economic Forum, 2023). This dynamic environment necessitates a responsive and adaptive approach to curriculum development to prevent skills misalignment between graduates and industry requirements (Desha 2009, Chua 2020).

Authentic Learning in Higher Education Engineering

Creating learning environments that include engineering workspaces and laboratories to align to real-world tasks and context is an approach to authentic learning. The concept of authentic learning is likely to have first grown out from a body of work that sought to understand learning in workplace apprenticeships done by Brown, Collins & Duguid (1989). The study explained the importance of learning activities and environment are integral to cognition and learning. In this paper, the authors use the term "authentic learning" to describe learning that is supported by being situated in an environment that aligns learning objectives and activities with real-world tasks and context via Industry Academia Collaboration (IAC) (Kozanitis et al, 2009).

Authentic learning in higher education engineering is addressed notably within the CDIO Standards 3.0 framework as well. The CDIO framework facilitates authentic learning by immersing students in real-world engineering contexts that mirror professional practice. Standards 1 and 6 establish the conceiving, designing, implementing, and operating (CDIO) context and having suitable engineering learning workspaces respectively. The integration of appropriate learning environments and educating engineering students with the CDIO framework develops a holistic understanding of the challenges of engineering and the need to develop solutions in collaboration with others. Beyond setting the context and engineering workspaces to support authentic learning, Standard 12 (program evaluation) is important for authentic learning as well. A study by Cheah (2022) suggested the need to make reflective practices explicit in the CDIO framework. The Mirror-Microscope-Binoculars metaphor was introduced in the study to illustrate three levels of reflection for the continual improvement of academia programs. This emphasis on reflective practice is more important than ever, due to the rapid developments in technology and world events today. The following will review various studies of authentic learning in higher education through IAC:

A study by Mejtoft (2015) reported that students from Umea University, Sweden, successfully collaborated with media group VK Media to renew their digital news platform. The applied physics and electronics students developed digital platforms such as websites and mobile applications for the media company to keep up with technological changes. The author reported that the industry-academic collaboration following the CDIO framework led to higher levels of engagement from both students and industry. Standards like Active Learning and Design-Implement Experiences made students more aware of the actual problem and have a better professional attitude towards the project and results. Other than higher student engagement, another study by Tiewtoy et al (2019) reported that due to IAC, their agricultural engineering students have gained better employability and enhanced their faculty professional development to work with industry. The study highlighted their 5 steps IAC process: 1) university visit, 2) student internship, 3) industry visit, 4) industry-based co research and 5) co-develop curriculum which incorporates CDIO standards like integrated curriculum, integrated learning experience and enhancement of faculty competences to be key reasons why the IAC was successful. Many industry companies are classified as Small and Medium Enterprises (SMEs), and unsuccessful IAC can be costly to their finances. As such Bridgewood and Sorensen (2020) reported a successful IAC between students from Technical University of Denmark (DTU) and manufacturing company, where the industry placed students are able to transfer their knowledge to subsequent students to ensure project continuity and success. The study reported that due to the increased IAC, the students met various CDIO standards like learning outcome, design-implement experiences and integrated learning experiences as well. Lastly, a study by Jaca et al (2021) reported their experience with IAC where their Industrial Engineering students from the University of Navarra, Spain worked with a machine tool company. The students visited the company and had specific sessions with the engineers of the company to reinforce their learning. The study reported that their students positively value the challenges posed by the company, and that the project was developed in the company's environment. The positive feedback encouraged the university to continue their IAC.

Alignment to SP Education Model

In Singapore Polytechnic, strategic partnerships with industry must be meaningful, purposeful and enable robust value exchange between parties. By integrating industry partners directly onto the campus, the institution ensures that students and staff are exposed to the latest technologies and practices. This aligns with one of the four key pillars of our SP Education model shown in Figure 1, supporting authentic learning and industry readiness across all SP courses. In essence, the overarching considerations for our SP Education Model are derived from the 3-pronged guidance given to us by Ministry of Education (MOE) namely PET (Pre-employment training), CET (Continuing Education & Training) and Industry Engagement (IE).

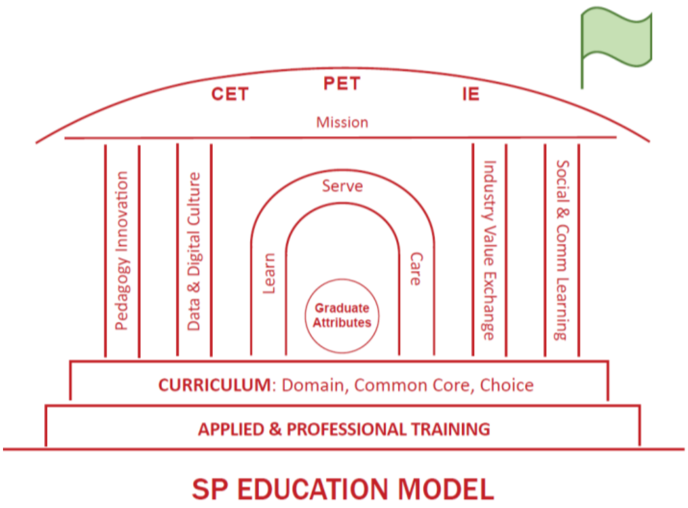


Figure 1. SP Education Model

The Co-lab approach ensures that we remain current with domain-specific trends and technological developments, enabling our students to experience curricula that are relevant to industry needs. Through authentic learning experiences, students develop knowledge and skillsets that are directly applicable to current industry practices, bridging the gap between academic theory and real-world application.

CDIO in Singapore Polytechnic and SP Engineering Cluster

Engineering education requires a structured framework that effectively guides the redesigning of our curriculum to constantly meet the learning needs of our students. The sustained implementation of CDIO has established it as a key approach in Singapore Polytechnic's Engineering Education Ecosystem. In the next section of the paper, a holistic review on the adoption of CDIO for Engineering Education referencing EEE, Diploma of Electrical & Electronic Engineering (DEEE) as case study is shared.

The 3-year DEEE programme in Figure 2 begins with a Common Core Curriculum (CCC) that equips students with essential human and digital skills crucial for success in a rapidly evolving world. As student progresses from this foundation, they advance through a comprehensive technical journey: starting with engineering fundamentals in Year 1, including mathematics, circuit analysis, and basic programming; moving to intermediate concepts like microcontroller programming and communication systems in Year 2. In the final year, students can choose from one of the seven specialisations to deepen their domain knowledge. This specialisation pathway, combined with industry internships, and flexible electives that allow students to explore their passions or tailor their study to specific career goals, ensures graduates emerge as well-rounded, industry-ready professionals with both technical expertise and practical experience.

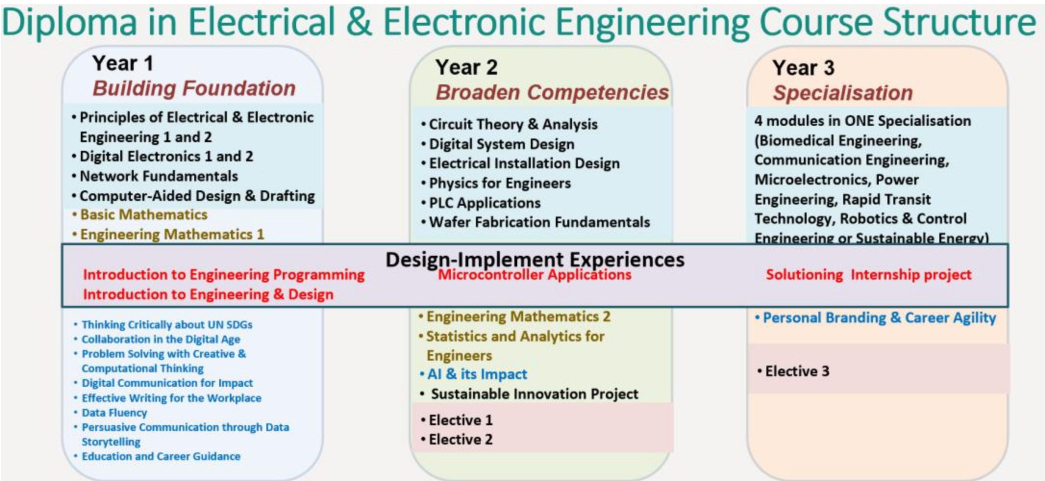


Figure 2. CDIO approaches across DEEE student learning journey

The integration of the CDIO framework across the 3-year curriculum in Figure 2 and Figure 3 demonstrate a progressive approach towards scaffolding the learning and building the students' competencies and confidence as they progress into their senior years of studies. While the first and second years establish foundational knowledge through structured laboratory settings, the third year marks a significant transition towards industry-focused learning. This culminates into a Solutioning Internship where students apply their specialised knowledge in real-world contexts. The Co-lab approach further enhances this authentic learning experience by bringing industry partners directly into the campus environment. This approach creates a seamless bridge between academic theory and professional practice, where students engage with genuine industry challenges whilst remaining within the supportive campus ecosystem.

<table>
<tr>
<td>Year 1: IED and IEP

Year 2: Microcontroller Application</td>
<td>CDIO Standard 4: Introduction to Engineering

CDIO Standard 5: Design - Implement Experience

CDIO Standard 8: Active Learning</td>
<td rowspan="2">CDIO Standard 3: Integrated Curriculum

CDIO Standard 6: Engineering Learning Workspaces

CDIO Standard 7: Integrated Learning Experience</td>
</tr>
<tr>
<td>Year 3: Solution Internship</td>
<td>Students apply their specialised knowledge in real-world contexts</td>
</tr>
</table>

Figure 3. DEEE students transition from lab to industry

The structured progression from controlled laboratory experiences to industry-integrated projects effectively transforms the traditional learning environment into an authentic workplace setting, preparing students for the complexities of real-world engineering challenges.

SP Engineering Cluster Industry Engagement

Singapore's RIE2030 strategic framework (National Research Foundation, 2025) recognises that navigating global economic shifts and technological disruptions requires sustained investment in research and innovation, particularly through intensified R&D efforts in high-impact sectors and horizontal enabling technologies with cross-sector applications. Singapore Polytechnic's Co-lab initiative aligns with this research and innovation focus by fostering industry-academia partnerships to build resilience and maintain Singapore's competitive edge as an advanced manufacturing and connectivity hub. The Ministry of Education's Planning Guidance for the Polytechnics and ITE for Financial Year 2026 further reinforces this alignment by establishing four key priorities that the Engineering Co-lab is uniquely positioned to address. The guidance's emphasis on industry relevance focuses on developing work-ready graduates with relevant skills in an AI-pervasive world through closer partnerships with employers and authentic work experiences through internship and Work-Study Programmes (WSP). The Co-Lab initiative exemplifies this approach by facilitating industry-academia collaboration. Similarly, the priorities of lifelong learning, comprehensive student support, and enhanced teaching practices create a framework within which the Engineering Co-lab can serve as a catalyst for continuous skills development, inclusive learning environments, and innovative pedagogical approaches that prepare students for an evolving technological landscape.

The SP Co-lab initiative is operationalised for Engineering students through the Engineering Cluster Industry Engagement Centre (CIEC), which drives strategic partnerships with industry to achieve these objectives. By leveraging the combined expertise and resources of both schools (EEE and MAE), including lecturers, students, equipment, curriculum, and training materials, CIEC facilitates impactful collaborations across electrical, electronic, and mechanical engineering domains. CIEC adopts a structured engagement framework via its Industry Engagement Platform, starting with identifying value propositions, formalising partnerships through Memorandum of Understanding (MoU), allocating collaborative spaces, and assigning mentors. This is shown in Figure 4. Industry-relevant student projects and internships are supported through structured mentorship by both faculty and industry experts. The engagement approach presented could serve as a reference blueprint for SP future potential industry partnerships engagement in establishing Co-lab set up.

Figure 4. CIEC Industry Engagement approach

Co-lab Implementations and Benefits

Singapore Polytechnic's Engineering Co-lab addresses the challenge of providing authentic industry learning experiences by creating industry-integrated learning spaces that bridge the gap between academic theory and practical application. These centres and laboratories provide immersive learning and hands-on training, preparing students to meet the demands of the evolving technology landscape. Beyond just having a better holistic understanding of the industry, the continuous feedback from industry partners will enable staff (course chairs and teaching members) to constantly review their curriculum and materials ensuring relevancy to the industry.

The EEE Co-labs serve as a cornerstone for fostering technology-specific advancements and industry-academic collaborations, with each lab dedicated to a particular technology domain pertinent to its industry partner's needs. These labs are strategically integrated with EEE's eight tech hubs (SP EEE, 2025), which organise and allocate staff and resources based on specific technological capabilities and domains, ensuring a focused and relevant learning environment. Similarly, the MAE Co-lab (SP MAE, 2025) creates value exchange through a collaborative ecosystem that nurtures both industry transformation and student development. Through the Advanced Manufacturing Learning Journey (SP-AMLJ), students engage in hands-on experiences that bring Industry 4.0, AI and sustainability concepts to life. Through these collaborations, students from SP's engineering cluster gain exposure to current industry trends and opportunities to engage in real-world projects. This enriches their learning experiences, building their competency in both technical and social skillset mimicking real job which is beyond their daily curriculum studies. To determine how different stakeholders (students, staff and industry) benefit from the Co-labs, a survey was conducted to gather views on the learning outcomes and experiences from the Co-lab initiative. The surveys looked at several areas, including authentic learning experiences, technology trend awareness, application of CDIO in projects and collaborative dynamics, providing insights into how the industry partnerships are improving student learning and skill development within the Co-lab environment.

SURVEY FINDINGS

In this section, the survey results from different stakeholders from Co-lab space will be discussed. Three distinct surveys were separately conducted across different stakeholder groups: Students, Lecturers, and Industry partners. The surveys were based on a 7-point Likert scale and examined the various dimensions outlined above, with particular focus on the bridging of academia-industry gaps and the facilitation of collaborative innovation, as well as project outcomes and organisational benefits.

Students in Co-lab workspace

From the student's perspective, a total of 43 students (EEE and MAE) from the past two semesters with interactions in Co-lab workspaces provided their input. Figure 5 presents the data for students' experiences in gaining better insight into technological trends of the industry. Analysis from the surveyed data reveals that most respondents (30 out of 43, 70%) indicated a "Somewhat large" to "Very large extent" of insights gained, while only a small fraction (4 out of 43, 7%) reported minimal impact.

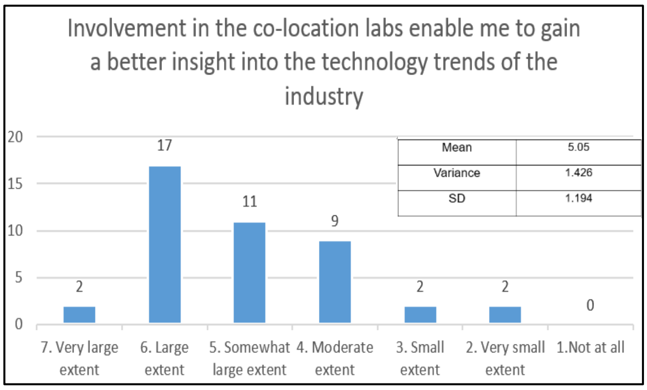


Figure 5. Student data (Insights into technology trends of the industry)

Due to the strong industry presence within the Co-lab workspace, the involvement by students significantly enhances participants' understanding of industry technology trends. This reinforces the notion that Co-labs serve as an invaluable platform for institutions to keep students connected with industry technological advancements.

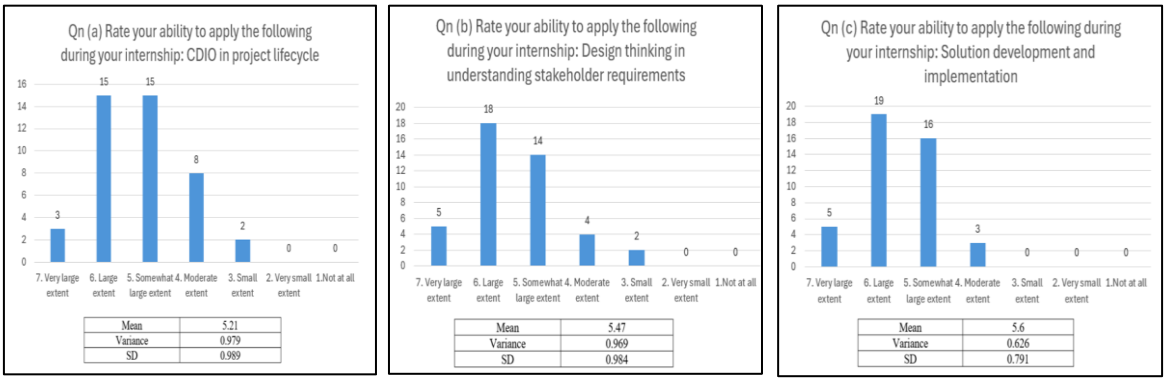


Figure 6. Student Data (CDIO in project lifecycle, DT and solution development)

Figure 6 Qn (a) examines the students' proficiency in applying CDIO for their projects during internships. This provides insights into how this framework addresses the fundamental challenge of integrating industry partnerships with authentic learning experiences. During internship, each student works on their projects through conceive, design, implement, and operate stages. The result reveals that most respondents (33 out of 43, 77%) indicated a “Somewhat large” to “Very large extent” of proficiency in the application of CDIO during internship, while only a small fraction (2 out of 43, 5%) reported minimal application. There are no respondents for options of “very small extent” and “not at all”. These findings strongly suggest that CDIO provides students with an effective framework to navigate and execute their internship projects. Figure 6 Qn (b) and (c) show a notably positive response on students’ self-assessment, their ability in application of Design Thinking, solution development and implementation. For application of Design Thinking skillset, 37 out of 43 interns (86%) rated their ability at "Somewhat large" to “Very large extent”. Similarly, in solution development and implementation, 40 out of 43 interns (93%) rated their ability at "Somewhat large extent" or higher. These results show that students developed foundational knowledge and skillsets through their earlier years of study reflected in Figure 2, effectively translate into practical competencies in design thinking and solution implementation during their internship.

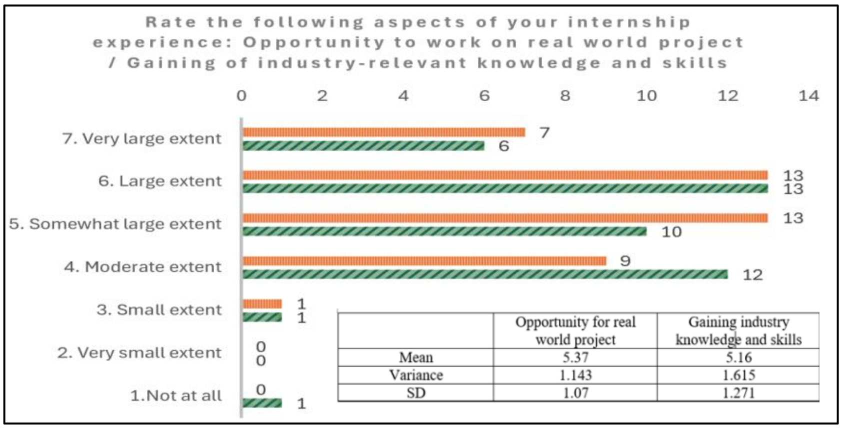


Figure 7. Student data (real-world project and industry relevant knowledge)

Figure 7 presents the students’ surveyed results on the opportunity to work in real-world projects and gaining skillset and knowledge relevant to industry while interacting in the Co-lab workspace. The results show that the responses generally cluster in the mid to upper range

(Likert 5-7, 77% - Opportunity to work on real world project, 67% - Gain Industry relevant skill and knowledge). The distribution shows a moderate positive skew, with mean ratings above 5.0 for both aspects. There are minimal responses in the lower ranges, with only one response each for "Small extent" and notably, one response for "Not at all" in gaining industry-relevant knowledge. These findings strongly support the strength of Co-labs in achieving authentic learning outcomes, where students are immersed in genuine industry environments enhancing their learning experience.

In the next section, the observations from the focus group discussions will be shared and discussed to gain a deeper insight and understanding of the survey data.

Focus group observation

A focus group discussion with 10 students was conducted with aim of gaining deeper insights into the survey responses and better understanding the underlying factors influencing students' learning experiences in the Co-lab. Through this qualitative approach, students were encouraged to share their perspectives on the authentic learning environment, industry project experiences and CDIO applications. The session was recorded and transcribed for analysis, with key themes and representative quotes extracted. The focus group discussion revealed several key observations as follows:

<u>Authentic Learning:</u> Participants noted that working in Co-labs differs significantly from traditional classroom learning. They emphasized the freedom to explore and tackle real-world problems, which enhances their learning experience.

<u>Application of CDIO in Projects:</u> The discussion highlighted the application of CDIO during the students' internship projects. Participants shared challenges faced during the conception and implementation stages, with many finding the implementation phase particularly difficult due to troubleshooting and design iterations.

<u>Real-World Project Experiences:</u> Participants discussed the challenges of working on real-world projects, including the need for self-directed learning and the importance of collaboration with peers and supervisors. They noted that real projects require them to bridge the gap between academic knowledge and industry requirements.

<u>Skill Development:</u> The focus group revealed that participants gained both technical skills (e.g., programming languages) and soft skills (e.g., communication and presentation skills) through their experiences in the Co-labs.

<u>Collaboration and Peer Learning:</u> The importance of exchanging ideas and seeking advice from peers and experienced staff was emphasized as a valuable aspect of their learning process.

<u>Challenges in the Industry:</u> Participants acknowledged the difficulties of adapting to industry standards and the need for continuous learning to keep up with technological advancements.

The focus group findings complement the quantitative survey results, providing deeper insight into how the Co-lab model facilitates authentic learning.

Staff for Co-lab workspace

From the stakeholder staff's perspective, a total of 24 (Engineering Cluster - EEE and MAE) staff provided their input. Table Qn 1(a) denotes the results from the staff survey. The data supports the Co-lab's notion in creating an authentic learning environment within the campus ecosystem. With 92% of staff “Strongly agree” or “Agree” that the lab enables the staff to achieve desired learning outcomes with students. In addition, the positive response (100%) from Table Qn 1(b) regarding the lab's role in bridging academia-industry gaps indicates how this approach helps integrate academic theory with professional practice. This highlights the value of bringing industry partners into the campus environment to enhance student learning experience.

Table 1. Survey data from Staff on Co-lab

Questions	Responses	Stats
Qn (a) The industry co-location lab learning space enable me to achieve the desired learning outcomes for my students.	7. Strongly Agree (50%) 6. Agree (42%) 5. Partially Agree (4%) 4. Neutral (4%)	Mean: 6.38 Variance: 0.592 SD: 0.77
Qn (b) The industry co-location lab contributes to bridging the gap between academia and industry practices.	7. Strongly Agree (50%) 6. Agree (50%)	Mean: 6.5 Variance: 0.261 SD: 0.51
Qn (c)The industry co-location lab provides a means for staff to keep pace with latest industry trends.	7. Strongly Agree (67%) 6. Agree (25%) 5. Partially Agree (8%)	Mean: 6.58 Variance: 0.428 SD: 0.654
Qn (d) Industry co-location labs at SP enhance collaboration between academic and industry partners.	7. Strongly Agree (58%) 6. Agree (42%)	Mean: 6.58 Variance: 0.254 SD: 0.503

Table 1 Qn (c) demonstrates the lab's contribution toward staff development, with 67% “Strongly agree” and 25% “Agree” about the Co-lab providing a means for staff keeping pace with industry trends. Lastly, staff endorsement (Strongly agree, 58% and Agree, 43%) of enhanced academic-industry collaboration indicates that the Co-location model supports the progression from laboratory experiences to industry-integrated projects. These ratings across all dimensions suggest that Co-labs create an environment where staff and students can both benefit from the close engagement with industry, bringing closer the academia and industry gaps.

Below are some of the sampled qualitative comments from Staff:

Qn: Can you provide specific examples on significant project outcomes that is achieved with the collaboration of Co-lab with industry?

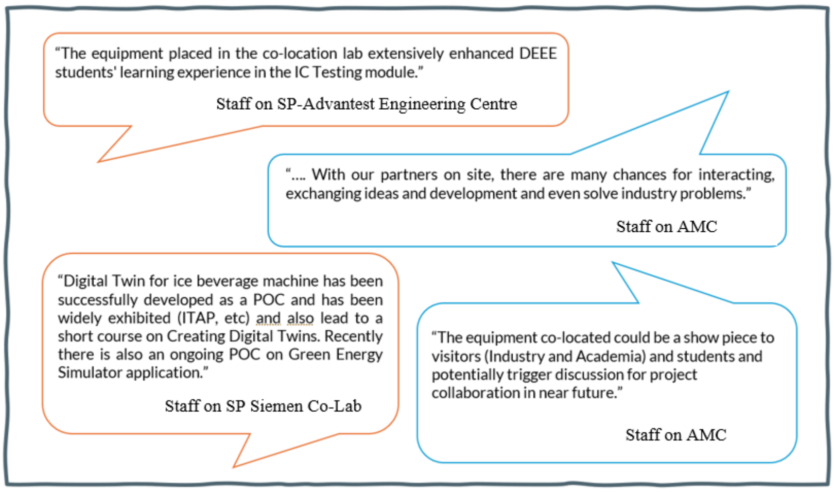


Figure 8. Qualitative comments from Staff

Industry partners for Co-lab workspace

From the stakeholder industry partner's perspective, 8 partners provided their quantitative and qualitative feedback.

Table 2. List of Participating Companies for Survey

Participating companies	
1. Aquapro Solutions Pte Ltd 2. Advantest Singapore Pte Ltd 3. Chint Singapore 4. Singtel	5. Siemens Industry Software Pte Ltd 6. Haimer Singapore Pte Ltd 7. Shenhao (Singapore) Pte Ltd 8. Astech Pte Ltd

Table 3 presented the survey data from Industry Partners on Co-lab. The industry partners' feedback indicates positive outcomes across the three survey questions and shown in Table Qn 3(a). For collaborative innovation, 75% (6/8) strongly agreed and 25% (2/8) agreed that the lab strengthens collaboration and innovative solutioning between stakeholders.

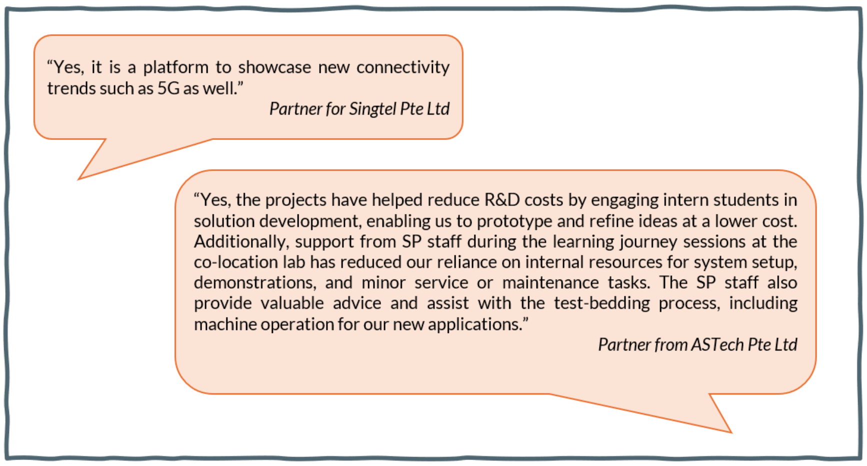
Table 3. Survey data from Industry Partners on Co-lab

Questions	Responses	Stats
Qn (a) The co-location lab approach strengthens collaboration and innovative solutioning between staff/ students and industry for the project.	7. Strongly Agree (6 out of 8) 6. Agree (2 out of 8)	Mean: 6.75 Variance: 0.214 SD: 0.463
Qn (b) The project/s outcomes delivered by SP students participating in project/s in the industry co-location lab meet my expectations.	7. Strongly Agree (4 out of 8) 6. Agree (4 out of 8)	Mean: 6.5 Variance: 0.286 SD: 0.535
Qn (c) The industry co-location lab strengthens SP Engineering Cluster (Consists of SEEE/ MAE)'s reputation for industry engagement and innovation.	7. Strongly Agree (6 out of 8) 6. Agree (2 out of 8)	Mean: 6.75 Variance: 0.214 SD: 0.463

Project delivery effectiveness shared in Table Qn 3(b) showed an equal distribution, with 50% (4/8) strongly agreeing and 50% (4/8) agreeing that student project outcomes met expectations. This balanced response on project outcomes reflects the challenging nature of industry projects, which require students to develop self-directed learning capabilities and acquire new technical skills independently to meet project requirements. Regarding institutional reputation in Table Qn 3(c), 75% (6/8) strongly agreed and 25% (2/8) agreed that the lab enhances SP Engineering Cluster's standing in industry engagement and innovation. These results demonstrate that the Co-location model successfully facilitates industry-academic collaboration while fostering student development through authentic industry project experiences. This integration of industry partnerships within the Co-lab has fostered mutually beneficial relationships, where companies gain access to innovative solutions while contributing to student development through authentic industry projects.

Sample Qualitative Comments from Industry Partners:

<u>The projects or initiatives undertaken with SP-EEE/ MAE's students and staff have been beneficial to my organization.</u>



Provide details on specific project/s or initiatives facilitated by the industry Co-lab that have led to tangible outcomes or intangible benefits to your organization?

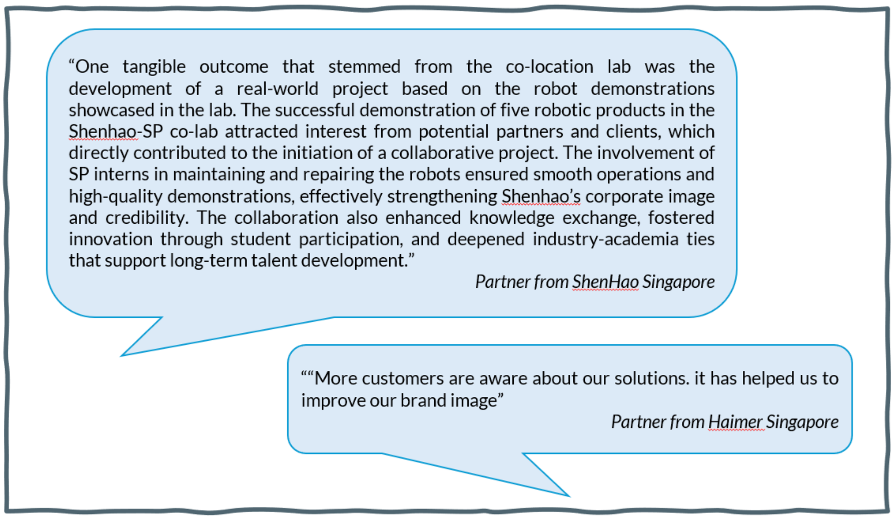


Figure 9. Qualitative comments from Industry Partner (benefits to organization)

The consistently positive feedback across all survey dimensions in Figure 8 and Figure 9 demonstrates a win-win collaboration model that strengthens both institutional and corporate brand reputation in the technology education space. This successful partnership between academia and industry creates sustainable value for all stakeholders, enhancing SP's standing as an innovation partner while providing industry partners with access to emerging talent and fresh perspectives.

In the next section, the reflection on the studies and discussion of future works is presented followed by the conclusion of the paper.

REFLECTION AND FUTURE WORKS

The survey findings from this study provide valuable insights into the effectiveness of the Co-lab in delivering authentic learning experiences. The results show that the Co-lab approach presents a strong alternative for SP students to gain authentic learning compared to traditional company internships. Key success factors include ensuring structured industry engagement and forming strategic partnerships through careful evaluation of value propositions that benefit both students and the school, while maintaining clear alignment of collaboration objectives.

With the CDIO framework infused into our engineering curriculum, the scaffolding of foundational knowledge and skillsets enables students to take on more complex challenges, such as authentic real-world projects during their internship. The Co-lab approach provides the ideal engineering workspace, real-world problem from industry, and guidance from experts and mentors for students to undertake such projects during their internship.

Survey findings across students, staff, and industry partners validate that this integrated approach not only enhances students' technical competencies but also develops their professional skills through authentic industry exposure.

This sensing study, while informative, represents a preliminary exploration of the Co-lab model's effectiveness. The current findings suggest positive outcomes across stakeholder groups, but deeper longitudinal studies are needed to fully understand the impact on student learning outcomes and skill development.

1. **Tradition internship vs Co-lab (Student):** The relationship between traditional internships and Co-lab experiences requires further investigation. While both approaches aim to provide authentic learning experiences, their relative effectiveness in achieving specific course objectives and learning outcomes need more detailed examination. Future studies could compare learning outcomes and experience between traditional internship programmes and Co-lab-based learning. Initial findings suggest that Co-labs offer unique advantages in providing consistent, structured learning experiences while maintaining the benefits of industry exposure.

2. **Staff Development and Learning (Staff):** Reviewing the work from another perspective and viewpoint, the impact of Co-labs on staff development has emerged as an interesting area to further explore.

   From this work, some of the future research could examine:

   - Expanded studies on experiences of staff attachment programmes within Co-labs compared to company attachment
   - How industry exposure through Co-labs influences teaching methodologies
   - The development of industry-relevant expertise among academic staff

Moving forward, these areas of investigation could help in refining the Co-lab implementation and maximising its potential for delivering authentic learning experiences. A more comprehensive understanding of these aspects will enable better alignment between academic objectives and industry requirements, ultimately leading to more effective preparation of engineering graduates for their professional careers.

CONCLUSION

This work demonstrates that the implementation of Co-labs, guided by the CDIO framework, offers a systematic approach for tertiary institutions to address the challenges of delivering authentic learning experiences in engineering education. Through the implementation of Co-labs within the SP Engineering Cluster, we have observed how this industry-academia partnership approach effectively bridges the gap between theoretical knowledge and practical application. The survey results across different stakeholders supported by the focus group studies demonstrate that Co-labs create an environment where students engage with emerging technologies, industry-standard equipment, and real-world challenges, thereby enhancing their learning experiences and industry readiness.

ACKNOWDGEMENTS

The authors received no financial support for this work. We would like to thank all reviewers for their time and constructive feedback, which helped strengthen this work. The authors acknowledge that generative artificial intelligence was employed as an assistive tool for grammatical corrections and improving sentence clarity in the preparation of this manuscript.

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