APPRAISING CDIO STANDARDS FOR GUIDING RESPONSIBLE GEN AI USE IN CURRICULUM DESIGN

Sin-Moh Cheah

Department of Educational Development, Singapore Polytechnic

ABSTRACT

This paper explores how the 12 CDIO Core Standards can continue to be used to guide curriculum design or redesign in the advent of generative artificial intelligence (GenAI) which use had been impacting the educational sector flaming expectations and raising concerns. The paper first gives a brief outline of the use of GenAI in teaching and learning, in particular the concern over their use in assessment. Concerns over excessive dependence of GenAI use in teaching and learning are also discussed. The paper then goes into detailed discussions of the plausible use of GenAI in each CDIO Standard. The analysis is based on the premise that all required input for machine learning are available and curated in the format appropriate for creation of customized GenAI. While this is likely not reflective of status of most institutions, the purpose is to expose faculty to the possibility of GenAI in addressing the needs of a given standard. Taking each standard in turn, areas where GenAI can be used to improve faculty efficiency and effectiveness when applying the standard are discussed, and published work is referenced if available. This is followed by highlights of areas where faculty review of GenAI responses are deemed necessary to maintain human-in-the-loop oversight. Use of GenAI in learning assessment in particular, in given a "light touch" given the on-going debate over the legitimate use of the technologies in providing genuine representation of student learning. This paper identify 4 key areas where use of GenAI, in its current state of technologies advanced as they may be – can still pose significant challenges if used for curriculum design or redesign Key takeaways from this paper is that the author does not recommend the use of GenAI in designing CDIO-type integrated curriculum and in performing self-evaluation for CDIO program evaluation. These 2 aspects should decidedly remain a human endeavor.

KEYWORDS

Responsible GenAI, Human-in-the-Loop, Collective Intelligence, CDIO Standards 1-12

INTRODUCTION: SCOPE OF THIS PAPER

Back in 2023, updating on the World Economic Forum Annual Meeting in Davos on January 16-20, Narayan & Larsen (2023) reported that Generative Artificial Intelligence (GenAI or Gen AI) is a game-changer that society and industry need to be ready for. Today, GenAI has emerged as a revolutionary technology with a wide array of applications, notably within the educational sector (e.g. Krause *et al*, 2025). It posed unprecedented challenges to education and faculty must critically examine the integration of these technologies into academic teaching and learning processes (Kurtz *et al* 2024; Bobula, 2024) over a range of concerns including biases, discrimination, data privacy, cheating and plagiarism, copyright issues etc.

This paper is not meant to be a critical appraisal of GenAI in teaching and learning, especially in areas of assessment, which probably received the most attention. Readers interested in this topic can refer to other works such as Belkina *et al* (2025), Bobula (2024), Giannakos *et al* (2024), Gonsalves (2025) and Mehdipour (2025).

The main emphasis here is to review how the current iteration (i.e. version 3) of the CDIO Standards can be used to guide their use in curriculum design in the advent of GenAI, where many processes can be performed using GenAI. The work is to support a model introduced by the author (see Cheah, 2026a) that uses CDIO Standards as a “layer of protection” to engage faculty in deep thinking when relying on GenAI to assist in design/redesign one’s curriculum using CDIO Framework. The aim is to provide an approach that can assist faculty in navigating the responsible use of GenAI in higher education. Kurtz *et al* (2024) defined responsible AI as referring to the practice of designing, developing and deploying AI systems in a way that is ethical, fair, transparent and accountable.

The handling of GenAI also warrants that humans develop new sets of skills and attitudes and the term AI Literacy immediately came to mind. Markauskaite *et al* (2022) went beyond knowing AI Literacy to focus on human cognitive capacities, values and joint knowledge practices needed for success in a world with AI. There is also a need to strengthen existing skills and attitudes – especially foundational ones such as creativity and critical thinking, sense-making and decision-making from being eroded to guard against over-reliant of GenAI use – skills and attitudes deemed the “core” elements that differentiate humans from machines.

After a brief introduction of how GenAI is used in general in teaching and learning and in CDIO community, we continue with the review of each standard in turn and discuss how GenAI can be used along with the key principles espoused in the standard. This paper concludes with suggestions on how best to implement “human-in-the-loop” strategies for designing and reviewing CDIO-type curriculum given the current state of GenAI technologies.

BRIEF OVERVIEW ON USE OF GEN AI IN TEACHING & LEARNING

GenAI poses unprecedented challenge to academic learning and teaching methods (Tillmanns *et al*, 2025; Wall *et al*, 2025; Kurtz *et al*, 2024). The content for this section largely derived from the work of Bozkurt *et al* (2024) who prepared an excellent study of the positives and negatives of GenAI use in teaching and learning with the aim of establishing a balanced perspective by critically analyzing both its challenges and affordances. It is crucial that we as humans be mindful that any activities of GenAI are not self-driven but depend on programed and pre-trained inputs supplied by GenAI providers. There is always a risk that GenAI become a technology that reduces students’ critical thinking and independent problem-solving skills.

instead of fostering deep engagement with the learning material. Over-reliance on GenAI could lead to surface understanding and a reduction in effort, where students bypassing challenging cognitive tasks that are essential for developing expertise and long-term retention. The reduction of cognitive load may inadvertently suppress students' ability to handle complexity on their own. The shielding of students from such cognitive struggle by GenAI risk producing students who are adept in using tools but lack the cognitive depth to navigate novel challenges independently. Over-reliance on GenAI could also diminish the value of peer-to-peer exchanges, where emotional intelligence, empathy, and social cues are crucial in learning.

The area of learning assessment is the one that perhaps garnered the most discussions in academic circles and publications. Based on the results of a systematic review of assessment for learning using technology, Memarian & Doleck (2024) argued that such studies still lacked a technological perspective such as AI. There had been concerns over the impact of over-reliant on GenAI that compromised students' cognitive abilities and its impact on learning. A study from Zhai *et al* (2024) suggested that students are increasingly favoring fast (and perceived optimal) solution over slow ones constraint by practicality, accounting for the reason why "cognitive shortcuts" offered by GenAI are preferred even amidst the ethical issues. Pallant *et al* (2025) conducted a study on students learning using GenAI and compared 2 approaches to learning: mastery vs procedural. Results showed that students with a mastery approach achieved a higher level of learning where GenAI is used to construct and augment knowledge. In contrast, using GenAI procedurally without augmenting knowledge (i.e. procedural approach) resulted in lower-level learning outcomes. Students on the other hand, often contested allegations of them cheating using GenAI, for example on grounds of vicissitudes of trust in students vs. technology, and raising questions of constituted cheating (Gorichanaz, 2023). Rundle *et al* (2019) reported in their studies that only a small percentage (about 3%) of students engaged in contract cheating. The main reason for not doing so is morality and motivation for learning. Indeed, Reynoldson (2025) argued that more focus should be placed on fostering greater trust between faculty and students, than agonizing over prevention of student cheating.

The broad consensus from the academic community in addressing the use of GenAI in education is one that called for more AI-resilient curriculum (Nagelhout, 2023). AI-resilient is defined by FeedbackFruits (2025) as "…building learning experiences that are resilient by design – experiences that foster the kinds of thinking, creating, and connecting that GenAI alone cannot do". An AI-resilient curriculum would feature authentic real-world applications that requires high level of critical thinking, creativity, decision-making and problem-solving skills. This makes the CDIO Framework very well suited to serve as a powerful tool to provide guidance to programs seeking to integrate use of GenAI in the curriculum.

GEN AI & THE CDIO FRAMEWORK

The current version of the CDIO Framework (i.e. version 3) was the result of a review and updates back in 2020 to cater for developments in 4 areas: sustainable development, digitalization, services and faculty competences (Malmqvist *et al*, 2020). Although digitalization was addressed, the main change is limited to Standard 6 to highlight the role of digital technologies in the learning workspaces that support and enhance the quality of teaching and student learning. The advent of GenAI, however, is more far-reaching in that it can impact all the 12 core standards.

Currently, the exploration of GenAI and CDIO Standards is only emerging in the 2024 International CDIO Conferences where several papers discussed specific instantiations of GenAI use to enhance teaching and learning based on specific CDIO standards. For example, Kimpton *et al* (2024) reported on how generative AI can support active learning environments (CDIO Standard 8) and integrate diverse learning preferences into the engineering curriculum (CDIO Standard 7). Ajailia *et al* (2024) shared a course that provided ethical education to AI to graduating students. Zerai & Mosbeh (2024) shared the use of challenge-based learning within an AI project for an AI engineering curriculum. Kamoun *et al* (2024) suggested using GenAI to help faculty in designing effective assessments (Standards 10 & 11). Saeidlou *et al* (2024) reported on the use of GenAI to support the conceive, design, implement and operate stages of a module on Engineering Product Lifecycle. What is interesting in the last paper is the authors' deliberate effort to use learning tasks that make it challenging for students to look for answers using GenAI. There was o specific discussions on how GenAI affected the CDIO Standard per se.

Likewise in the 2025 International CDIO Conference, several papers covered use of GenAI in enhancing teaching and learning. Toh *et al* (2025) presented the development of an AI-powered feedforward tool designed to support students in designing effective prompts in using and engaging critically with GenAI, consistent with the requirements of CDIO Standards 1, 2, 3, 7, 8, and 11. Likewise, Hidila & Tabaa (2025) described using development of an AI coding assistant that addressed requirements of CDIO Standards 2, 3, 5, 7, 8 and 11. Guettat *et al* (2025) shared work done in creating a personalized life learning environment using GenAI, which introduce active learning (CDIO Standard 8) to support lifelong learning.

APPLICABILITY OF CDIO STANDARDS VIS-À-VIS GEN AI

This paper aims to provide comprehensive coverage of the CDIO Standards and address how GenAI can be used alongside each Standard. It expands on the use of each Standard, elaborates on how some of the principles embodied in each standard can potentially be performed by GenAI. In the following sections, each standard is discussed with reference to how use of GenAI can support the application of the standard. Areas where GenAI use is applicable will be presented, and where appropriate, extant literatures where it had been used will be shared. Areas where the outputs from GenAI appear questionable will be highlighted. It is important to note that the discussions here *presuppose that the necessary knowledge base are available as inputs for the GenAI engine used*. In other words, it is assumed that retrieval augmented generation (RAG) technique had been applied to enhance the large language model (LLM) used with institution-specific requirements, and program-specific information. Each section will conclude with our recommendations for faculty involvement in the use of the respective standard, stressing the importance of "human-in-the-loop".

Use of GenAI in CDIO Standard 1 The Context

CDIO Standard 1 emphasizes real-world context in engineering education. Today, this must include the pervasive role of GenAI across the engineering lifecycle of conceiving, designing, implementing, and operating sustainable products, processes, systems, and services; as briefly explained below:

- *Conceiving*: GenAI can help students summarize findings from external scans, identify trends and key issues, generate solution ideas, and draft proposals or business plans.
- *Designing*: GenAI can accelerate design by identifying regulations and standards, generating options and drawings, and supporting rapid prototyping and material selection.

- *Implementation*: GenAI can aid in manufacturing planning, software code generation, testing automation, and process optimization through data analysis.
- *Operating*: GenAI can compile manuals, prepare maintenance protocols, and draft troubleshooting guides, enhancing system reliability.

Given GenAI's reach, students must be introduced at an early stage to their capabilities, limitations, and ethical use. CDIO Standard 4 *Introduction to Engineering* is a suitable entry point for developing AI literacy, data fluency, and responsible attitudes.

Human-in-the-Loop Oversight for CDIO Standard 1

Faculty must critically review GenAI outputs, especially during problem identification, to ensure relevance to local contexts and stakeholder needs. This is vital when addressing "wicked problems" with conflicting viewpoints. Oversight helps guard against bias, cultural insensitivity, and over-reliance on dominant paradigms.

Use of GenAI in CDIO Standard 2 Learning Outcomes

CDIO Standard 2 emphasizes the formulation of learning outcomes that reflect the competencies needed by graduates (Pinski & Benlian, 2024). In the age of AI, two key facets must be addressed:

- *Integration of New AI-Driven Competencies:* Industry 4.0 and the rise of GenAI have introduced roles such as prompt engineer, data scientist, and AI ethicist. With Industry 5.0 on the horizon (Doven *et al*, 2025), demands for AI literacy and ethical awareness are intensifying (e.g. Allen & Kendeou, 2023; Laupichler *et al*, 2022). The United Nations Educational, Scientific and Cultural Organization publication *AI Competency Framework for Students* (UNESCO, 2024) outlines four domains – human-centered mindset, AI ethics, AI technologies and applications, and AI system design – across three proficiency levels: Understand, Apply and Create. GenAI can support STEEP (Social, Technological, Environmental, Economic, Political) analysis to identify emerging domain-specific skills and attitudes and help structure their progression using models like Dreyfus' five-stage skill acquisition framework (Dreyfus, 2004).
- *Strengthening Foundational Cognitive Capacities:* To support AI-related competencies, foundational skills such as critical and creative thinking, metacognition, decision-making, and resilience must be reinforced. These hybrid capacities underpin effective engagement with GenAI and are essential for adaptive problem-solving (Krause *et al*, 2025; Nguyen *et al*, 2025; Zhai *et al*, 2024).

Human-in-the-Loop Oversight for CDIO Standard 2

Faculty must ensure that learning outcomes drafted by GenAI must match the proficiency levels specified for the local industry job roles and responsibilities. Learning outcomes must also be validated with key stakeholders to ensure alignment with industry needs. Although GenAI can assist in analyzing survey data, faculty must review the insights and ensure outcomes are properly aligned with course-level goals, graduate attributes, and professional norms. Further discussion on learning outcomes will be expanded under Standard 11 *Learning Assessment*.

Use of GenAI in CDIO Standard 3 Integrated Curriculum

CDIO Standard 3 requires that AI Literacy and GenAI competencies be integrated into program curriculum and planned for progressive development across the program duration of study. Students should be made aware of the limitations of GenAI, its ethical use and risks to their cognitive development associated with over-reliance on GenAI. The UNESCO *AI Competency Framework for Students* mentioned earlier offers a useful reference. However, it is worth noting that AI Literacy needs to be tailored for different user groups (Pinski & Benlian, 2024). Beyond AI Literacy, other emerging competencies can be embedded using the usual CDIO approach. GenAI can assist by mapping integration points across the curriculum and suggesting learning activities to support competency development. These strategies will be elaborated in Standard 7 *Integrated Learning Experiences*.

GenAI instruction should address both general and domain-specific knowledge. Students should understand GenAI's contributions to productivity and innovation, while also critically examining its impact on privacy, equity, and social norms. Domain-specific integration should align with disciplinary contexts, consistent with CDIO principles.

Human-in-the-Loop Oversight for CDIO Standard 3

Curriculum integration demands careful faculty oversight. GenAI may struggle with contextual reasoning due to limitations in relevant training data and lack of program-specific granularity. Local documents may not succinctly capture all nuances, limitations and constraints of a program are not available for coding as inputs for the RAG/LLM. Faculty must iterate prompts, review outputs critically, and apply tacit local knowledge of program structure. Even well-crafted prompts cannot compensate for incomplete or flawed input data. This challenge will be further explored by later standards. Challenges in using GenAI for designing program structure will be addressed in greater detail later.

Use of GenAI in CDIO Standard 4 Introduction to Engineering

CDIO Standard 4, which calls for an introductory course that prepares students for engineering practice, must include early exposure to GenAI. This foundation course should inform students of GenAI's benefits, limitations, and ethical implications. It should emphasize responsible use of GenAI in knowledge creation and professional conduct. Environmental and societal impacts can also be introduced, such as the energy demands of data centers powering the LLMs, as well as risks of bias, discrimination, and inequity in GenAI systems developed by commercial entities. These cross-cutting issues offer students a critical lens on the broader consequences of technological advancement.

Human-in-the-Loop Oversight for CDIO Standard 4

Faculty should lead the design and delivery of this course to ensure contextual relevance. GenAI may lack awareness of local industry structures, regulations, and governance. Faculty oversight is essential to embed local perspectives and ensure that students develop a grounded understanding of engineering responsibilities in their specific context.

Use of GenAI in CDIO Standard 5 Design-Implement Experiences

CDIO Standard 5 emphasizes authentic design-implement experiences. GenAI can propose projects of increasing level of difficulty across the program duration, support student engagement in several ways:

- *Extending Domain Knowledge*: GenAI can aid students in acquiring project-relevant knowledge through self-directed learning. However, faculty must guide responsible use, as the volume and speed of GenAI-generated information may overwhelm students or lead to superficial understanding if they are not critically engaged.

- *Supporting the CDIO Lifecycle*: GenAI can assist learning across the four stages — conceive, design, implement, operate — as outlined in Standard 1 *The Context*. Nikolic *et al* (2025) demonstrated how AI can comprehensively support project activities throughout this lifecycle.
- *Simulating Interdisciplinary Perspectives*: GenAI can emulate input from other disciplines, enriching project work with diverse viewpoints. This is especially valuable when interdisciplinary collaboration is impractical. Jones (2023) highlights how GenAI can help students tackle complex, transdisciplinary challenges.

Human-in-the-Loop Oversight for CDIO Standard 5

Faculty must ensure that projects proposed by GenAI are aligned to local contexts. Faculty must emphasize human creativity, especially during the "conceive" stage. While GenAI may outperform humans in idea quantity, its outputs often lack diversity and depth. Poon *et al* (2024) found that human-generated ideas tend to be more varied and higher in quality. Faculty should encourage students to exercise their own creativity and critically evaluate GenAI suggestions. Faculty must also ensure GenAI-generated ideas do not infringe copyrights or patents. In addition, for projects with industry sponsors, it is recommended that faculty consult his/her industry counterparts on the acceptability of proposal(s) or suggestion(s) from GenAI.

Use of GenAI in CDIO Standard 6 Engineering Learning Workspaces

CDIO Standard 6 emphasizes the importance of engineering learning workspaces. With the rise of digital technologies, these spaces are increasingly hybrid – blending physical and digital environments. While digital spaces are gaining prominence, full replacement of physical workspaces is neither feasible nor desirable. Faculty can leverage GenAI across both modalities to deepen student engagement (Parsons *et al*, 2019).

On campus, flipped learning has reduced reliance on large lecture halls, while Smart TVs in seminar rooms foster collaborative learning where GenAI supports students' personalized learning through data analytics. Laboratory automation can also leverage GenAI to analyze operational data to optimize equipment utilization and resource conservation. Increasing use of digital twins can be coupled with GenAI to further enhance learning (Boareto *et al*, 2025). The DTALE (Designing Teaching and Learning Environments) Model developed by Tondeur *et al* (2024) offers guidance for integrating physical and digital spaces effectively.

GenAI can streamline equipment procurement by comparing vendor proposals against program requirements, especially for off-the-shelf items. For customized equipment, GenAI can suggest configurations based on performance specifications and intended learning outcomes. It can also assist in facility layout planning, ensuring compliance with safety regulations (e.g. spacing, evacuation routes, fire protection). For existing facilities, GenAI can optimize utilization by identifying opportunities for cross-program equipment sharing and scheduling.

Human-in-the-Loop Oversight for CDIO Standard 6

Facility management, which can be led by a faculty, must collaborate with course owners to identify local requirements that GenAI may overlook. These include utility tie-ins, drainage routing, cable routing, and "wet areas" or designated waste collection point. Human insight remains essential to ensure safe, functional, and contextually appropriate learning spaces.

Use of GenAI in CDIO Standard 7 Integrated Learning Experiences

CDIO Standard 7 emphasizes learning tasks that mirror professional engineering practice in the workplace. GenAI can support this by generating realistic workplace scenarios and preparing instructional materials, from experimental protocols to task-specific guides, thus enhancing the richness of student experiences. GenAI is also very useful in assisting faculty in generating task-specific performance rubrics. However, faculty must review GenAI-generated content to avoid reinforcing biases or overly prescriptive tasks that limit student growth (Bozkurt *et al*, 2024).

GenAI is particularly effective in competency-based learning, such as Direct Observations of Practice (DOP) (Chan, 2008). Whether in physical labs or virtual simulations, GenAI can analyze performance data and provide targeted feedback. Video analytics, for example, can help faculty assess student actions in pilot-scale chemical plants and highlight areas for improvement in real time.

Human-in-the-Loop Oversight for CDIO Standard 7

Faculty must ensure GenAI-generated scenarios are contextually appropriate, free from bias, and aligned with the students' level of study. Sequencing integrated tasks across a course or program requires nuanced understanding that GenAI alone cannot provide. Faculty must design tasks that preserve the pedagogical intent of integrated learning experiences, using GenAI to support a mastery-oriented approach where students prioritize competence development over grades (Pallant *et al*, 2025). The tasks should not be overly prescriptive, restricting students to the content they already find manageable (Bozkurt *et al*, 2024). Faculty should encourage students not to overuse GenAI to assist with task responses, by explaining that doing so risks bypassing critical steps that foster metacognition and learning agency.

Use of GenAI in CDIO Standard 8 Active Learning

CDIO Standard 8 promotes using active learning strategies to foster deep engagement. GenAI can enrich these strategies across face-to-face and online settings, from simple Think-Pair-Share to complex Role Play and Debate. When GenAI acts as a "critical friend" or mentor, it facilitates dialogic learning by engaging students in meaningful conversations. Faculty can exercise creativity in using GenAI, for example by adapting GenAI as a virtual peer in traditional Think-Pair-Share, responding to student input and prompting deeper reflection. As a teaching assistant, GenAI can pose follow-up questions to stimulate critical thinking. In debates, GenAI can provide counterpoints that simulate diverse perspectives, broadening students' understanding. Other methods, such as one-minute papers critiquing GenAI-generated content or analyzing hallucinated outputs, can strengthen cognitive skills and metacognition. For faculty teaching in a "smart" classroom, GenAI enables near real-time instructional adjustments by automating feedback analysis. It can support teaching improvement through sentiment analysis of student reflections (e.g. "clear-as-mud" topics), helping refine active learning approaches.

Human-in-the-Loop Oversight for CDIO Standard 8

While GenAI's immediate feedback can correct misconceptions, it may also introduce new ones or encourage superficial understanding (Bozkurt *et al*, 2024). To mitigate this, students should be taught reflective practice and self-regulation. Faculty can assign tasks that require critical evaluation of GenAI-generated response to deepen learning (Abdelghani et al., 2023; Bozkurt et al., 2024).

Use of GenAI in CDIO Standard 11 Learning Assessment

CDIO Standard 11 focuses on assessing students' skills and attitudes in authentic contexts. In the extant literature, many discussions had centered on issues of integrity and security of an assessment system, and on how much GenAI use is permitted during examinations. This is due to the concern that with increasing sophistication of GenAI tools, it is increasingly difficult to distinguish students' original work from that completed using GenAI. This is especially for reflective tasks that was once thought immune to GenAI.

For the perspective of CDIO, assessment now faces two challenges: (1) evaluating new competencies like AI Literacy, and (2) safeguarding core skills such as critical thinking from erosion due to over-reliance on GenAI. A related challenge is the choice of assessment methods and the needed evidence of learning. The first is manageable through constructive alignment, as with other CDIO-based competencies. The second requires more deliberate design. "AI-resilient assessment" refers to tasks that retain educational integrity despite GenAI's capabilities. These assessments are not meant to be "AI-proof" but rather robust against inappropriate GenAI use by prioritizing process over product, requiring deeper cognitive engagement, and incorporating elements beyond text, such as reflection, interaction, and real-world application. However, as pointed out by Fawns (2024) assessment that focus on processes can also be problematic, on what actually got assessed.

Alternative approaches include allowing use of GenAI in parts of a task, followed by critical evaluation of its output. Moorhouse *et al* (2023) propose five themes for redesigning assessments: testing GenAI tools, rethinking task design, staging assessments, integrating GenAI, and using in-class formats. Examples include:

- Rewarding ethical and responsible GenAI use in complex problem-solving
- Reviewing student-submitted prompts in formative tasks
- Summative reflections critiquing GenAI-generated responses

Corbin *et al* (2025) advocate structural changes to assessment design that constrain how students interact with GenAI, moving beyond mere policy enforcement which is a "discursive" approach as currently practiced. Structural changes to assessments are modifications that reshape the underlying mechanics of the assessment tasks themselves, thereby directly influencing or constraining how students can interact with GenAI. Gonslaves (2025) recommends "contextual assessment," which is a framework that incorporate multiple layers of contextual complexity, that moves beyond professional realisms alone.

Human-in-the-Loop Oversight for CDIO Standard 11

As noted in the overview section of this paper, assessment with or without GenAI is a hotly debated area. The discussion here is deliberately broad to stay focused on the principles of assessment of diving into on-going debate on GenAI use in assessment. Faculty must design AI-resilient assessments constructively aligned with integrated learning experiences (Cheah, 2026a). A balanced approach that values GenAI as a learning companion while preserving student agency is key. Krause *et al* (2024) highlights differing priorities: academics focus on ethics and policy, while students prefer practical AI applications. Assessments should reflect both, reinforcing AI Literacy and contextual learning in line with CDIO principles.

Use of GenAI in CDIO Standard 12 Program Evaluation

CDIO Standard 12 promotes program-level evidence-based continual improvement via a self-evaluation process. GenAI offers promising capabilities in many aspects, such as automating data collection, performing sentiment analysis, identifying gaps, generating scoring rubrics, and executing evaluations (Patel, 2023). While these benefits are well recognized, significant challenges remain. Unlike conventional evaluation, GenAI often generates data algorithmically, while humans interpret outcomes manually, creating a disconnect in validity and context.

The adage of GIGO (garbage in, garbage out) remains relevant. With machine learning and LLMs, flawed or incomplete input data can yield unpredictable outputs. This is especially problematic when GenAI is used to evaluate curriculum outcomes, where delivery over time can and often introduce variables that GenAI may not capture, such as shifts in student engagement or instructional nuance.

Current CDIO rubrics are broad and not easily parsed by GenAI for precise analysis. Building a robust, structured knowledge base for machine learning would require significant investment in academic management systems. Without this foundation, GenAI-generated evaluations risk lacking validity and contextual relevance.

Human-in-the-Loop Oversight for CDIO Standard 12

Faculty must critically assess GenAI's role in program evaluation. While automation can streamline processes, human oversight is essential to interpret results meaningfully, account for delivery nuances, and ensure alignment with intended learning trajectories to guide meaningful and impactful action plans for curriculum improvement. At present, cautious adoption is advised until data infrastructure and rubric precision are sufficiently developed. These points will be further elaborated in the later discussions.

Use of GenAI in (revised) CDIO Standard 9 Enhancement of Faculty CDIO Competencies and (new) CDIO Standard 10 Faculty Continuing Professional Development

Cheah (2026b) proposed revisions to CDIO Standards 9 and 10: absorbing Standard 10 into Standard 9 and rename the new Standard 9 as *Enhancement of Faculty CDIO Competencies* and refocusing Standard 10 on sustained professional growth and titled *Faculty Continuing Professional Development*. Under Standard 9, faculty must be equipped with AI Literacy to effectively integrate GenAI tools into CDIO-aligned teaching. They also serve as human-in-the-loop, ensuring ethical and responsible GenAI use. Standard 10 calls for continuous renewal of AI competencies to stay relevant in a rapidly evolving technological landscape.

GenAI can support both standards by automating training needs analysis, curating relevant programs, and serving as a virtual coach to guide faculty through personalized learning pathways. It can track progress, recommend additional training, and adapt to evolving professional demands. These capabilities help faculty stay current with AI advancements and integrate GenAI tools responsibly into CDIO-aligned teaching.

Human-in-the-Loop Oversight for CDIO Standards 9 & 10

To fulfill their role as human-in-the-loop, faculty must maintain ethical oversight of GenAI use in education. This requires continuous renewal of AI Literacy and critical engagement with emerging technologies. GenAI should scaffold faculty thinking – not replace it. As Bozkurt *et al* (2024) cautioned, the line between augmentation with GenAI and its dependency is thin, therefore professional development must guard against passive dependency and instead promote active cognitive engagement.

OVERALL DISCUSSIONS

The brief summary of what GenAI can and cannot support, and the required human responsibilities when using each of the 12 CDIO Core Standards is shown in Table 1.

Table 1. Summary of what GenAI can or cannot support and human-in-the-loop

CDIO Standard	What GenAI Can Support	What GenAI Cannot Support	Required Human Responsibilities
1 – The Context	Summarize issues, generate ideas, prepare proposals, automate design drawings, assist prototyping, and compile manuals.	Handle "wicked problems," balance conflicting viewpoints, ensure cultural/local relevance.	Validate outputs, review for bias, ensure stakeholder fit.
2 – Learning Outcomes	Suggest AI-related competencies, organize findings, draft outcomes using Bloom's Taxonomy.	Specify proficiency levels accurately, capture local industry context.	Align outcomes with graduate attributes, validate with stakeholders.
3 – Integrated Curriculum	Map AI literacy integration suggest learning activities, support progressive skill development.	Capture tacit knowledge, nuanced program structures, contextual constraints.	Refine prompts, validate curriculum design, ensure ethical integration.
4 – Introduction to Engineering	Introduce GenAI concepts early, highlight benefits/pitfalls, raise awareness of social/environmental impacts.	Provide local industry context, legislation, governance details.	Design and deliver course content relevant to local context.
5 – Design-Implement Experiences	Support project stages (conceive, design, implement, operate), simulate interdisciplinary perspectives.	Generate diverse, high-quality creative ideas; avoid copyright/patent issues.	Reinforce human creativity, validate originality, ensure responsible use.
6 – Engineering Workspaces	Suggest layouts, optimize utilization, streamline procurement, support digital twins and analytics.	Capture local facility requirements (utilities, drainage, safety specifics).	Validate layouts, ensure compliance with safety rules, adapt to local constraints.
7 – Integrated Learning Experiences	Suggest workplace scenarios, prepare manuals, design competency-based tasks, provide feedback via analytics.	Avoid reinforcing biases, stereotyping, or overly prescriptive tasks.	Validate scenarios, sequence tasks, promote mastery learning.
8 – Active Learning	Act as virtual peer/mentor, provide counterpoints in debates, automate feedback analysis, suggest case studies.	Prevent superficial understanding, avoid introducing misconceptions.	Teach reflective practice, self-regulation, critically assess GenAI content.
9 – Enhancement of Faculty CDIO Competencies	Assist in designing CDIO-type tasks, provide assessment tools, update disciplinary knowledge.	Replace reflective practice, tacit judgment, or authentic role modeling.	Engage in reflective practice, update knowledge, ensure ethical GenAI use.
10 – Faculty Continuing Professional Development	Provide training resources (prompt engineering, rubrics, analytics), suggest insights for teaching/research.	Replace institutional frameworks, evaluate long-term impact, substitute live training.	Conduct training needs analysis, participating in CPD, evaluation and updating competence.
11 – Learning Assessment	Draft rubrics, analyze reflections, automate sentiment analysis, suggest formative/summative questions.	Ensure fairness, set difficulty levels, align assessments with outcomes.	Validate rubrics, calibrate difficulty, ensure constructive alignment.
12 – Program Evaluation	Compile survey data, analyze trends, generate reports, identify improvement areas.	Interpret nuanced stakeholder feedback, contextualize cultural/industry needs.	Review evaluation results, align with institutional goals, act on findings.

To fully leverage GenAI's potential, a robust academic knowledge base must be developed: one that captures a wide spectrum of structured, contextualized data for training large language models (LLMs). This requires significant investment in academic management systems capable of curating curriculum metadata, assessment artifacts, and instructional nuances. However, deploying GenAI at the program level presents several persistent challenges:

Ambiguity in curriculum content and context: GenAI may lack access to the full curriculum structure, needed prior knowledge (especially if these are to be acquired outside stipulated curriculum hours), pedagogical intent in each course, etc. In addition, course syllabus and other documents may contain mistakes, e.g. wrong proficiency level implied due to choice of Bloom taxonomy used, some learning outcomes not captured although implemented in a course, etc. As a result, GenAI may resort to inferring progression logic, over-simplification, and misplacing advanced tasks too early.

Interdependency of competencies: Higher-order competencies are not standalone – they are built from foundational skills and attitudes (i.e. "skill to build skills) and deeply interwoven with other the technical domain and context under which they are practiced. Particularly hard to teach, and even harder to assess are attitudes, as they can be very context sensitive and affect by other factors, e.g. cultural. It will be challenging for GenAI to map such dependencies across courses and between integrated learning experiences if not provided with explicit relational data and may result in false alerts on possible gaps in the curriculum.

Student profiles: For obvious reasons of data privacy, plus potential for misuse, information on students' academic data will not be easily available for GenAI processing. GenAI will then design learning tasks without the full knowledge of students' prior knowledge, and other learning challenges, e.g. dyslexia or hearing impairment, etc. Supporting disadvantaged students cannot be met with one-size-fits-all learning interventions generated by GenAI without human review. Likewise, evaluating students' engagement with learning such materials can also be particularly challenging, especially for online learning such as asynchronous lessons.

Transparency of assessments: GenAI doesn't inherently know how skills and attitudes are developed, reinforced or assessed in actual implementation of the CDIO Integrated Curriculum. It may not have the granularity of different assessment methods used for any one course. The scaffolding or feedback mechanisms used may lie outside of the formal curriculum that are not captured by the RAG used. Consequently, GenAI may propose development stages that appear pedagogically sound but not practically possible, or it may unintentionally overload certain semesters with too many assessments.

Recommendations: Do Not Use GenAI for Standards 3 and 12

Given these limitations, this author recommends that design of integrated curriculum (Standard 3) and Program Evaluation (Standard 12) be led by a core faculty team, ideally under the stewardship of the program manager. GenAI should not be used for such endeavor. This preserves human oversight and leverages the distributed wisdom of educators; drawing on the tacit knowledge, contextual insight, and spontaneous idea generation. As French philosopher Pierre Lévy described, "collective intelligence" emerges when individual contributions resonate and build upon one another (Peters, 2015).

Program evaluation should likewise be team-based. GenAI's black-box nature, where the logic behind its analysis and recommendations remains opaque, poses risks in self-evaluation contexts. CDIO rubrics are broad and subject to varied interpretation; and such subjective inputs are not easily parsed by GenAI. Without consistent, high-quality data, GenAI's outputs may lack validity and defensibility.

At the time of this writing, the field of "curriculum analytics" is just emerging, and a review by De Silva *et al* (2025) concluded that the technology is still developing and its maturity level is still not satisfactory. A collaborative approach enables faculty to cross-calibrate evidence, reduce subjectivity, and produce explainable, consensus-driven evaluation outcomes. Moving forward, this process can also support the development of shared templates and data standards needed for the design of a comprehensive academic knowledge base, and paving the way for future GenAI integration in a more structured and palatable manner.

CONCLUSIONS

The emergence of GenAI marks a transformative inflection point in education – reshaping not only how teaching and learning are practiced, but also how curricula are conceived, designed, and delivered. Continuing with business as usual is no longer tenable. GenAI must be understood not merely as a tool, but as an active agent capable of communicating, interacting, and generating content on demand – thereby influencing the neurocognitive processes through which humans learn and think.

This paper extends the model introduced by Cheah (2026a), urging faculty to explicitly consider GenAI when applying the CDIO Standards. In doing so, educators can cultivate a deeper understanding of GenAI's limitations and reinforce the critical role of human-in-the-loop oversight to ensure that AI-generated outputs serve their intended pedagogical functions.

As faculty advocate for responsible GenAI use among students, they must also embody those principles in their own practice. Responsible integration requires discernment—especially when using GenAI to design learning tasks. This paper highlights potential pitfalls across teaching and learning domains, equipping faculty to navigate GenAI use with greater fluency and ethical awareness.

AI technologies, and GenAI in particular, will continue to evolve rapidly. Today's limitations may be resolved by tomorrow's innovations. The CDIO framework, when thoughtfully enhanced with GenAI, offers a structured and adaptable pathway for curriculum design that can keep pace with technological change.

Although this commentary is primarily theoretical, its implications merit empirical validation. Future research should explore how contextual learning and contextual assessment influence student engagement, critical thinking, and academic integrity across disciplines. Such inquiry will inform ongoing refinement of the framework, ensuring that teaching and learning remain rigorous, responsive, and resilient in an accelerating educational landscape.

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BIOGRAPHICAL INFORMATION

Sin-Moh Cheah is the Centre Director of the SP-CDIO Centre for Innovative Teaching and Learning; under the Department of Educational Development, Singapore Polytechnic. He is also the Master Specialist (Teaching and Learning) in the School of Chemical and Life Sciences, Singapore Polytechnic. He has more than 18 years of experience implementing CDIO in the Diploma in Chemical Engineering curriculum and had conducted various CDIO workshops for universities in Asia, for various disciplinary programs. His academic interests include curriculum revamp, academic coaching and mentoring, and using GenAI in education.

Corresponding author

Mr. Sin-Moh Cheah
Department of Educational Development,
Singapore Polytechnic
500 Dover Road, Singapore 139651
smcheah@sp.edu.sg