CDIO FRAMEWORK AND COGNITIVE SCIENCE: HUMAN-IN-THE-LOOP FOR GEN AI USE

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ABSTRACT

This paper present a mental model to help address on on-going discourse on the careless use of generative artificial intelligence (GenAI) technologies without understanding its potential pitfalls. While acknowledging the benefits of GenAI use, this paper focused on addressing the potential harm of GenAI misuse. It is especially meant for educators as they embraced GenAI and increasingly use it for various aspects of curriculum design or revamp, and in a case of academic expediency, leading to uncritical acceptance of GenAI outputs. They may also inadvertently slip in personal bias into the learning tasks designed to engage students in learning. This model was constructed based on an analogy with real-world applications in biological and engineering disciplines. The model combines extant AI ethical framework, constructive alignment and CDIO Standards to provide guidance to educators to use GenAI in a responsible manner – it does not advocate a complete ban of GenAI use in teaching and learning but a thoughtful, ethical and principled use that harness the power of GenAI to benefit students learning through the use of CDIO Framework. The paper first put forward an argument from cognitive science on the malleability of human brain that makes is susceptible to negative impact due to over-reliance of GenAI use. It posited that deliberate use of pedagogy or combination of pedagogies supported by CDIO Standards that stimulate cognitive engagement is a means to counter the deleterious effect of misguided GenAI use. Selected examples of human capacities from both cognitive and affective domains that are at risk of being compromised by GenAI misuse are identified. The model is then presented and key features explained, followed by a simplified example of how the model can be used. The paper then shares some limitations of the work done, and outlines areas of potential research where use of the proposed model; and concludes will a call for the development of greater trust between faculty and students over GenAI use; where transparency in the teaching and learning is of paramount importance – a factor that the proposed model strive to provide.

KEYWORDS

Generative AI, Cognitive Science, Human-in-the-Loop, Constructive Alignment, CDIO Standards: 1-12

INTRODUCTION: BRIEF DESCRIPTION & SCOPE OF THIS PAPER

Generative Artificial Intelligence (GenAI, or Gen AI in short) undoubtedly had created a storm in the education community (Qian, 2025; Tillmann et al, 2025; Wall et al, 2025; Cardona et al, 2023). Gonsalves (2025) highlighted the need for a nuanced strategy to integrate AI effectively into educational practices and charged that many current efforts "remain piecemeal and reactive rather than strategic and forward-thinking, risking a cycle of short-term fixes rather than sustainable transformation". She further noted that uncertainty persists about the best path forward despite widespread concern and numerous pilot initiatives and urged that "inaction is not an option: the evolution of pedagogy and assessment design is necessary to adapt to GenAI realities".

From his own study, this author noted that most of the current discussions on GenAI tended to focus on policies and ethical frameworks regarding its ethical challenges, governance, advantages and pitfalls, faculty and student perception on its use. With respect to students, many studies focused on increasing student engagement, for example, via the use of chatbots based on GenAI, adaptive system or personalized learning. For faculty, the main emphasis is on improving productivity through streamlining of previously manual processes related mostly to academic administration such as setting of assessment questions, automation of marking processes. The use of GenAI at program and course level tend to be very generic and filled with possibilities or claims of what GenAI can do in many aspects of teaching and learning without much deep analysis. Within disciplinary domains, use of GenAI is most extensively studied in areas of languages, information and communication technologies, writing and general education (Belkina *et al*, 2025; Wang *et al*, 2025). Comparatively there were not many publications in the domain of engineering. Within the CDIO community, use of GenAI first came into prominence at the 2024 International CDIO Conference in Tunisia.

This paper aims to contribute to the discourse from the perspective of curriculum redesign using the CDIO Framework. The purpose is to assist faculty in integrating GenAI into one's curriculum, guided by CDIO principles. This paper takes a different approach from extant literature. It extends the discussion on the responsible use of GenAI, starting with questioning what constitute "foundational core" that we seek to protect against proliferation of GenAI use (or misuse) among both faculty and students. The current discourse on "foundational core" included critical thinking, creativity and creative thinking, empathy, metacognition, self-regulated learning – skills and attitudes that are innate to human, something that machines are not able to replicate, or at least not yet. This paper goes even deeper, looking into the "foundations of foundational core" so to speak. The work in this paper leveraged on developments in neuroscience and cognitive science and argued that the ability of human to think and feel in ways that machine cannot, constitute the "the core" that needs protection. This paper proposes a model of GenAI for use in teaching and learning that incorporates CDIO principles as part of "human-in-the-loop" safeguards along with AI ethical framework to protect "the core" from being negatively affected by GenAI misuse.

NEUROSCIENCE & COGNITIVE SCIENCE: CONNECTION TO PEDAGOGY, TEACHING & LEARNING (INCLUDING ASSESSMENT)

Neuroscience and cognitive science are closely related but distinct fields that together aim to understand how the brain and mind work. Cognitive science focuses on mental processes that humans engage in such as memory, thought and decision-making; while neuroscience seeks to make sense of the biological mechanisms of the nervous system. Neuroscience provides the biological underpinning and mechanisms as basis for cognitive science's theories of mind.

Pedagogy in modern usage is most commonly defined in dictionaries as "the art, science, or profession of teaching". However, such a broad definition informed nothing about the word. In application, pedagogy encompasses the methods, strategies, and approaches used to facilitate learning and achieve educational goals, involving complex relationships between the educator, the learner, and the subject matter. Pedagogy is also shaped by different cultural, social, and political contexts under which it is used. This certainly did not make it any easier for a definitive definition, and as such the meaning of pedagogy is still hotly contested.

Recent developments in neuroscience had confirmed the scientific basis on the role played by human brains in teaching and learning (Holmes, 2019). Pedagogy based on cognitive science focuses on how the human brain works during the learning process, drawing on the memory of previously learnt materials, retention and recall; to inform teaching strategies that creates new learning by connecting to prior knowledge. Key principles include cognitive load management which take into consideration the limitation of human working memory, spaced learning with retrieval practices to strengthen long-term memory, etc. The discourse on cognitive science is sparse, where to the best knowledge of the author, there are only 2 publications to-date, with the work of Niewoehner *et al* (2011) being the first to emphasize the importance of incorporating learning from cognitive science into teaching and learning. Another work by Cheah *et al* (2016) reported on how to use the core principles of learning derived from cognitive science in the design of flipped classrooms.

There are now calls for faculty to be trained or at least exposed to the role of neuroscience in their professional development (Van Bergen, 2024; Chang *et al*, 2021). More specifically Waas *et al* (2023) advocated for pedagogical approaches that enhances faculty’s ability to foster metacognition skills in students; and integrate cognitive and psychological findings into faculty professional development.

Pedagogy as a Learning Strategy

Based on the “traditional” interpretation above, the pedagogy based on principles of cognitive science can be considered as intentional design towards teaching and learning requiring human effort to scaffold learning through the deliberate and thoughtful use of specific instructional methods, mediated by social and cultural context, which seek to progressively develop desired competencies aligned to learners’ stages of cognitive development.

Pedagogy as a Cognitive Manifestation

Expanding the notion of pedagogy in the advent of GenAI, this paper proposes to frame pedagogy as a manifestation of the human attempt to learn better, grounded in how our brains process information and use that information to make sense of our external world – in short: how we think and feel. In this sense, pedagogy is both a product of cognitive science and a tool to shape cognition. Pedagogy therefore is a structured response to the cognitive architecture of the human brain, as it relates to:

- How we perceive, process, and retain information, e.g. through sensory input, working memory, and encoding for storage in long-term memory
- How we construct meaning, e.g. via schemas, analogical reasoning and development of conceptual frameworks
- How we develop metacognition, e.g. self-awareness of factors affecting thinking such as emotion, use of learning strategies and reflection’ and hence how we interact with our external world

Cognitive principles provide useful considerations in the design of learning tasks, for example chunking, deliberate practice, retrieval practice, structured reflection, Socratic questioning, metacognitive prompts, etc. Pedagogy in turn promotes cognitive activity through methods like problem-based learning, case studies, flipped classroom, etc.

Pedagogy doesn't just develop cognition, but also actively shaping it. This highlights a unique reciprocal relationship between pedagogy and cognition, in that it can be viewed as both a mirror and a mold of human cognition, reflecting the dual nature of teaching. How we teach is based on how we think, and the teaching process in turn actively reshapes how we think.

Risk to Cognitive Functions from Over-reliant on GenAI

One of the concerns raised in the increased use of GenAI by students and faculty alike is that they can become increasingly reliant on GenAI in their learning process (i.e. cognitive outsourcing), to the extent that deep learning is compromised. From the perspective of neuroscience, this concern is certainly a valid one. This is due to the malleable nature of the human brain (also known as neuroplasticity of the brain) – it changes and adapts based on the dynamic interaction between our biology and our experiences, as our external environment changes (Bear, Connors & Paradiso, 2015; Doidge, 2008)

While this is a good thing for humans to continue learning new things, it is bad news for over-reliant on GenAI use. Over-reliance on GenAI can subtly erode the very cognitive functions that pedagogy is meant to cultivate. Overuse of GenAI can shortcut the cognitive effort required for deep learning, for example not expending the required mental efforts to read, interpret and understand the materials presented, or to empathize with the needy; and thus not making as many neural connections as desired. Without the durable neural rewiring needed for transfer, abstraction, or innovation; students and faculty can become passive consumption of information, developing only surface-level familiarity on a given topic.

More significantly, over-reliance of GenAI to summarize findings, generate insights, prepare visualization, can be detrimental to another key human capability – that of executive functions such as planning and organization, self-monitoring, managing emotion, etc. Generations of performance evaluation matrix with its own criteria, summaries of articles, and conduct of sentiment analysis producing key themes and the like by GenAI can weaken students and faculty's ability to structure ideas independently. This can arise as neural pathways got rewritten – due the malleability of the brain – in a way that no longer make use of the core.

Cognitive Science Basis of CDIO Framework

The CDIO Framework, although not explicit in its formulation that it derived from cognitive science, can be seen as a curriculum redesign approach (in terms of the CDIO Standards) that was informed by and aligned with the principles of cognitive science. Examples include the following:

- The outcome-based learning of CDIO, which emphasizes "learning by doing", with clearly defined learning outcomes for knowledge, skills and attitudes
- The progressive development approach in the design of Integrated Curriculum to prepare graduate with the desired proficiency level
- The learning process that stresses the simultaneous learning of knowledge, skills and attitude within the same learning context, closely mimicking that of real-world workplace requirements in active and preferably also in an experiential manner, e.g. Design-Implement Experiences and Integrated Learning Experiences
- The assessment process that prioritized learning via a series of timely feedback

- The continual improvement orientation that uses self-evaluation using the core standards as the approach to Program Evaluation

MODEL FOR GEN AI USAGE GUIDED BY CDIO AND AI ETHICAL FRAMEWORKS

This endeavor was inspired by the work of Liu & Bridgeman (2023) who proposed a “two-lane” approach to address challenges of GenAI in assessing students learning. They opined that Lane 1 is where the assessment *of* learning is situated, whereas Lane 2 is for assessment *for* and *as* learning. Lane 1 is secured in the sense that students undertaking assessments in this lane are not permitted to use GenAI in their work; whereas in Lane 2 students have complete freedom to use GenAI in whichever way they preferred, or not to use it. For these authors, the separation between the 2 lane is absolute, as they noted: “We do not foresee a viable middle ground between the two lanes. It needs to be assumed that any assessment outside Lane 1 (i.e. that is un-secured) may (and likely will) involve the use of AI”. Later, the role of GenAI appeared to have been “relaxed” for Lane 1 where the use is now at the discretion of the examiner (Liu, 2024). The “two-lane” approach has been both praised and criticized for its simplicity (Curtis, 2025; Reynoldson, 2025).

For our model, we have decided from the onset that it should be a holistic one, to bring together various disconnected topics as mentioned in the INTRODUCTION. The key feature is the use of CDIO Standards that can systematically guide faculty in the use of GenAI in teaching and learning, including assessment. The model will incorporate as is, application of relevant AI Framework the institution subscribed to. We deliberately leave out any specific reference to what is not permitted in GenAI use, and what is allowable and by how much. Instead the model will stress the importance of faculty oversight (human-in-the-loop) based on the AI Framework adopted, the use of appropriate pedagogies consistent with the learning context and desired learning outcomes. Effectively we layered on the familiar CDIO approach with additional considerations of responsible and ethical use of GenAI.

The model is shown in Figure 1 as comprising of a series of concentric tubes. This idea is heavily influenced by the author’s training background in chemical engineering, specifically in membrane-based processes used in desalination (production of freshwater from seawater), dialysis (filtering of blood) and gas separation (e.g. production of oxygen from air). The semi-permeable membrane selectively permits only one-directional flow of specific materials (such as desired product, or undesired waste, contaminant) that migrates from the inner tube to the annular area. The driving force that affects the transfer can be differences in pressure, concentration, etc.

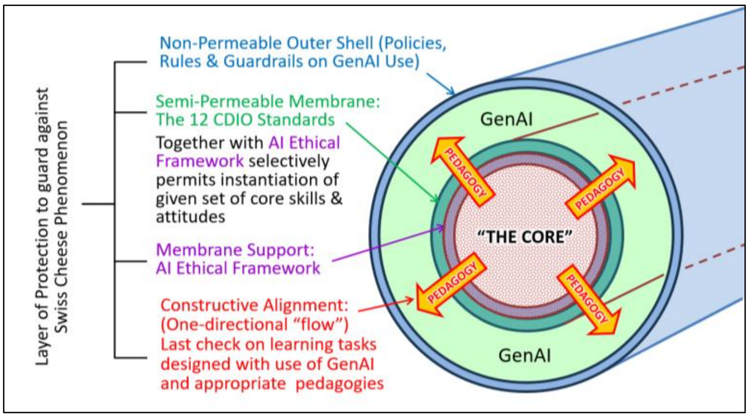

Figure 1. Model of GenAI use in T&L guided by CDIO and AI ethical frameworks

The innermost tube encompasses “the core” representing the ways humans think and feel, that we should develop in students, which needs to be shielded from being replaced by machines. Table 1 shows some elements in “the core” – human capacities from both cognitive and affective domains that at-risk human capacities at-risk of being eroded by over-reliance of GenAI use, as identified from the extant literature. The listing here is not exhaustive and is only to provide examples to justify why “the core” needs to be preserved as studies had reported on the potential downsides. This paper acknowledged that there are benefits of GenAI use. The absence of discussion in this paper did not imply that it is against GenAI use.

Table 1. CDIO syllabus describing “The Core”: Human capacities to be protected

Author(s)	Human Capacity	Key Insights from Paper
Chen *et al* (2025)	Emotional Regulation & Resilience	GenAI may lower cognitive effort, risking “cognitive atrophy” and reduced perseverance/resilience.
Fan *et al* (2024)	Emotional Regulation & Resilience	Reduced self-monitoring correlates with weakened motivation and resilience.
Gonsalves (2024)	Creative Thinking & Creativity	Stifled creativity when defaulting to AI-generated ideas; require AI-aware creative outcomes.
Lee *et al* (2025)	Critical Thinking & Judgment	High confidence in GenAI was linked to less critical thinking; and nature of critical thinking had *shifted* from *generating* and *analyzing* ideas to primarily *verifying* and *integrating* outputs from AI.
Moongela *et al* (2024)	Critical Thinking & Judgment	GenAI risks diminishing independent reasoning without scaffolded critique.
	Creative Thinking & Creativity	Heavy GenAI reliance reduces originality and divergent thinking.
Tomisu *et al* (2025)	Metacognition & Self-Directed Learning	Treating AI as “oracle” undermines metacognitive monitoring Outsourcing reflection to AI weakens SDL
Zhai *et al* (2022)	Critical Thinking & Judgment	Dependence on AI dialogue systems weakens decision-making and analytical reasoning.
	Metacognition	Overuse of AI reduces metacognitive engagement and verification.

The protection of “the core” is achieved by borrowing another concept in chemical engineering, that of layer of protection analysis or LOPA in short (see for example Willey, 2014). The concept of “defense-in-depth” in cybersecurity uses the same approach. Each layer of protection works independently of one another: If one layer of defense fails or is bypassed, subsequent layers are still in place to stop the attack or minimize its impact. Such layered security is designed to protect against the Swiss Cheese phenomena (Reason, 1990). This is a visual metaphor for accident causation in complex systems, where each slice of Swiss cheese represents a defense barrier with its own holes (weaknesses). Accidents occur when these holes align across multiple layers of defense, creating a clear path for a hazard to cause harm. The Swiss cheese model helps explain how failures arise from the combination of multiple, often minor, flaws, rather than a single catastrophic error.

The first protective layer (LOPA) surrounding “the core” is the AI Ethical Framework. In this paper, we made no specific recommendations on which framework to adopt. We noted that there are various authors and institutions that had already promulgated one’s own version of the AI Ethical framework. One notable framework is the Educational Integrity Enforcement Pyramid (Ellis & Murdoch, 2024). We will leave it to the program owner to decide on which AI Ethical Framework to use, to address the much-needed AI Literacy for faculty and students.

The second LOPA protective layer is the CDIO Framework, which together with the calibrated use of pedagogy or combination of pedagogies should guide the use of GenAI in various aspects of curriculum design. Different CDIO Standards will have their own constraints imposed on the acceptable use of GenAI. Due to page constraints, detailed discussions of the different CDIO Standards and how each of them guides GenAI usage is deferred to a separate paper by the author (Cheah, 2026a). Suffice to say that there are checkpoints in the CDIO Standards that ensure presence of “human-in-the-loop” to cross-check outputs produced by GenAI.

The use of GenAI in Figure 1 refers to the process of “Learning with AI” (Mattalo, 2024), which investigates the use of AI directly in pedagogical practices to assist students with learning or to assist educators with their teaching methods. To further protect “the core”, we borrowed a key understanding from object-oriented programming where we introduced the notion of “instantiation”, which is the process where one creates an instance of an object from the original blueprint. When you instantiate an object, you're bringing it to life for use in your program, and you then work with the instance of the object, leaving the original unaffected. This analogy implies that during humans interaction with GenAI when elements from the “the core” are needed, a “copy” of elements of “the core” is created and made available for use.

The arrows labelled “pedagogy” represents an intervention that seeks to leverage on GenAI to drive change in a program curriculum, for example, a series of learning tasks spread over the program duration to develop various CDIO skills and attitudes. The instantiation in this context means that the skills and attitudes embodied in “the core” had been “copied” for use alongside GenAI, to aid in desired aspect of the curriculum design effort, guided by relevant CDIO Standards; but leaving “the core” untouched by GenAI.

Next, we introduced the principles of constructive alignment into our model. The use of constructive alignment had been suggested by several authors (Schofield & Zhou, 2025; Stokkink, 2025) to systematically integrate AI literacy into curriculum design at the module level. Our model takes it one step further: constructive alignment as the ”last line of defense” in our LOPA concept mandating a check by “human-in-the-loop” after an intervention had been designed. We posited that CDIO Standards fit well with constructive alignment, as shown in Figure 2. The responsibility for ensuring alignment between learning outcomes, learning tasks and learning assessments will strictly be a human endeavor.

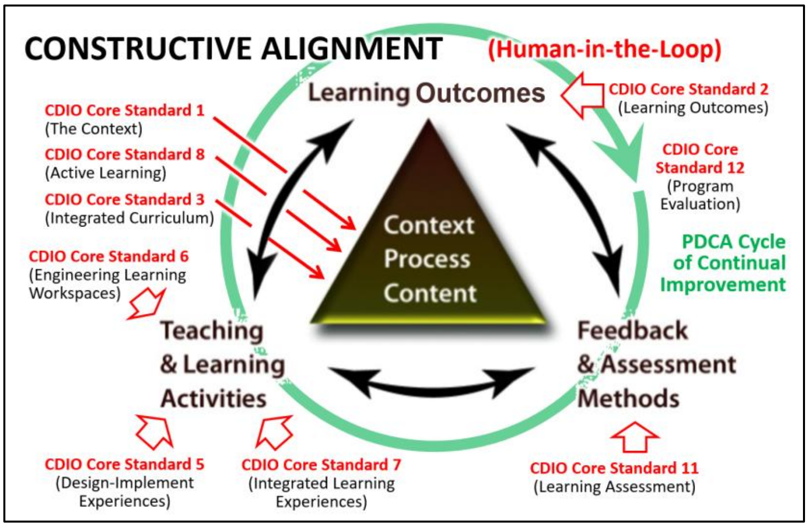

Figure 2. Constructive alignment and CDIO: Human-in-the-loop for GenAI use

In summary, our model emphasized a process approach to using GenAI in curriculum design, hence mandating faculty (human-in-the-loop) to consider the impact of using GenAI not only from perspective of its ethical use, but also in terms of protecting the core. As shown in Figure 1, pedagogy is not just a delivery system, it is also a neurological intervention. It specifically targets how humans think, being mindful of the influence of emotion in affecting the quality of thinking. It specifically requires faculty to make use of our long-term memory, drawing from the core (“instantiate”) when using GenAI on the design task on hand; and in the process, strengthen existing neural connections and create new ones.

The outcome of such protection against GenAI is therefore towards “cognitive independence”, which is explained as the ability to think critically, form personal judgements and make decisions based on one’s owned reasoned outcomes based on one’s own internal processing of information rather than by external prevailing opinions, which in this case, is the output from GenAI. By preparing learning tasks based on this model, faculty develop good practice of always checking on the appropriateness of using GenAI in every curriculum design situation; maintaining academic integrity and taking responsibility for GenAI use in education.

Example on How to Use the Model

As an example of how this model can be used, we consider processes in the design of a CDIO Integrated Learning Experience to integrate systems thinking in a hypothetical program in chemical engineering. The key steps are briefly listed in Table 2, showing where GenAI can be used and where human-in-the-loop is necessary:

Table 2. Using GenAI with human-in-the-loop for design of integrated learning experience

Task to be performed	Can be done by GenAI	To be overseen by human
Identify real-world workplace scenario where systems thinking is required	Suggest 2-3 scenarios, along with domain knowledge needed	Confirm the contextual factors and identify suitable course(s) with domain knowledge that match the scenario(s) identified
Write desired learning outcomes using Bloom Taxonomy	Suggest learning outcomes at different proficiency levels depending on task complexity	Check that the learning outcomes match that of the course and year of study, and aligned to institution’s graduate attributes
Design learning tasks using CDIO principles: including any scaffolding that are needed	Prepare a draft step-by-step learning task, suggest needed resources, suggest questions for pre-experiment (formative assessment) or in-experiment or post-experiment debrief (can be summative) Draft a scenario that require application of desired competency	Verify how realistic tasks can be carried out in school environment, e.g. through visualization, or actual prototyping in the laboratory Ascertaining prior knowledge had been covered elsewhere and of the right depth and breadth Ascertain relevance of scenario, e.g. mimic real-world environment
Define and design the learning assessment, and identify evidence needed	Produce performance rubrics for assessment – generic or task-specific to a scenario Suggest questions to be posed Performing sentiment analysis in the case where students are required to submit reflection journal	Review if performance criteria are appropriate, descriptors are clear and understandable by students and meet intended learning outcomes Confirm relevance of questions and level of difficulty commensurate with tasks performed
Review and improve on the designed learning task	Check for grammatical errors, fluency of language used, and professionalism in format used	Check for constructive alignment, and that the original intent had not been unintentionally modified

As mentioned earlier, Cheah (2026a) provides in a separate paper, presenting a standard-by-standard discussion on areas where faculty can use GenAI, and other aspects where human oversight (presence of human-in-the-loop) is recommended. Faculty should use that paper as a “design companion” when using CDIO Standards together with GenAI in their work.

LIMITATIONS AND IDEAS FOR MOVING FORWARD

Our model as depicted in Figure 1 was formulated from the perspective of guiding faculty in using GenAI in curriculum design in mind. It can be further envisioned that the learning tasks designed in this manner will also engage students in learning with AI in a responsible manner. Our students will graduate into a world where AI is already prevalent, no longer a distant concept. The mantra of being “work-ready” should now include competency to effectively navigate and thrive in a new world of AI.

However, the model is still a theoretical consideration and needs to be validated in practice. Along with our current efforts to develop sustainability mindset among students (Cheah et al, 2025), we can kickstart the testing of this model by using it to design some integrated learning experiences to develop various key competencies for sustainability. With the rapid advances in technologies, it is reasonable to expect more advanced and powerful GenAI engines will soon appear in the very near future. These developments may render parts of the protective layers ineffective. For example, the next iteration of wearable technologies will include detection of variations of biometrics of faculty using the GenAI engine. It may misinterpret increased heartbeat as potential negative impact of the activity being designed. The GenAI can potentially trying to “compromise” on the level of difficulty of the learning task; thus defeating the intended learning.

It may also appear trivial, the use of “instantiation” to protect “the core” suggested in the model. Unless faculty is familiar with object-oriented programming, doing so may appear strange. The model relied on an abstract notion “duplication” of skills and attitudes which did not actually took place in any design effort, hence it may be hard to appreciate how doing so can shield “the core” from negative impact of learning task produced by GenAI. We argued that it is the discipline of the thought process that matters. We want to make explicit to faculty to think of the pros and cons of each curriculum change scenario that the process becomes habitual. The reason behind this is again cognitive science and the malleability of human brain – the rewiring of our neural networks, so that the practice becomes second nature.

Another point worth highlighting is that our literature review specifically focused on negative impacts of GenAI use. The are of course, many papers that reported on the benefits of GenAI use, but for the purpose of this paper, these were deliberately omitted. This is by no means intended to discount the advantages of using GenAI in teaching and learning.

Moving ahead, we noted from Mattalo (2024) that research into the use of AI in pedagogy in general remains underdeveloped. Indeed, Mattalo (2024) charged that although GenAI is often lauded as a solution to many of educations problems, it is rarely used in any meaningful way to improve learning outcomes. Given the potential of GenAI, and the dearth of high-quality research into its intersection with pedagogical practices, he noted that there is a significant opportunity for academics to advance this field of research and suggested a framework of Learning with AI that comprises 3 focus areas, listed below and shown in Figure 3.

- *Pedagogical Enhancement Research*
- *Pedagogical Breakthrough Research*
- *Administrative Research*

This paper focuses on the 2 pedagogical research areas only, as *Administrative Research* is concerned with using AI to automate and alleviate the administrative load on faculty so that they can spend more of their time in teaching and learning as well as research practices on the capabilities of AI. *Pedagogical Enhancement Research* is concerned with studying the effectiveness of using AI to implement already well-recognized best practices in pedagogy with AI tools. *Pedagogical Breakthrough Research* is concerned with discovering new pedagogical practices that are unlocked by AI and were not possible in traditional learning environments. This latter area of research requires a deep understanding of how AI technologies work, may require training AI models on specific tasks, and will certainly require creativity and experimentation to uncover new methods of teaching that were not previously possible (Mattalo, 2024).

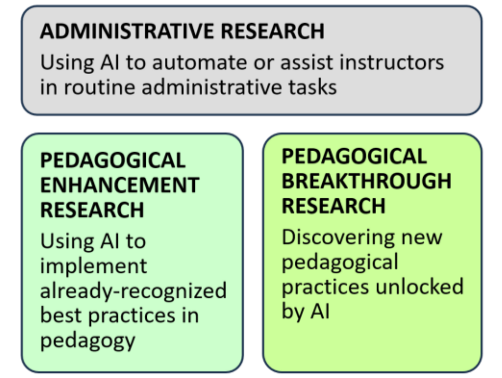

Figure 3. Modern learning with AI framework (adapted from Mattalo, 2024)

We can expect over the short-term that *Pedagogical Enhancement Research* will be the focus area, as more educators experimented with selected existing teaching and learning practices. Examples include AI-assisted previewing, AI-assisted questioning and feedback, AI-assisted group studying and AI-assisted personalized learning (Mattalo, 2024). Some examples of *Pedagogical Breakthrough Research* already being explored include prompt engineering, augmented reading and AI-based assessments. Over the longer run, it can be expected that new, innovative use of AI in teaching and learning will be introduced.

We believe that the model presented in Figure 1 will be able to support both *Pedagogical Enhancement Research* and *Pedagogical Breakthrough Research*. This is because the model was formulated to place greater focus on the learning processes rather than the outputs of GenAI. Notwithstanding that, it is worthwhile acknowledging the importance of balancing human expertise and integrity with GenAI capabilities when attempting curriculum innovation using GenAI (Francis et al, 2025). The author would speculate that *Pedagogical Enhancement Research* can be one area for investigating how “the core” can be strengthened using GenAI while being protected, for example, human creativity and creative thinking. And *Pedagogical Breakthrough Research* can drive innovations in teaching and learning, using enhanced human creativity and creative thinking, coupled with ethical and responsible use of GenAI.

Preliminary conceptualization of using GenAI for innovating teaching and learning practices was shared by Cheah (2026b) in his adaptation of the Rumsfeld Matrix to GenAI vs Human Intelligence. *Pedagogical Breakthrough Research* appears to be a promising way to explore the “unknown unknowns”, where both humans and machines do not know what they don’t know. Future work in this area will be shared at future conferences.

CONCLUSIONS

This paper presented an approach for faculty to use GenAI in an ethical and responsible manner, guided by a model backed by CDIO Standards, AI Ethical Framework and constructive alignment. It is hoped that greater transparency in GenAI usage can come to light using the suggested approach. This can be beneficial to foster greater trust between faculty and students, or students' perceived faculty distrust in them using GenAI to cheat (Reynoldson, 2025). It can be said that initial response among educational institutions when GenAI first came into the scene is one of suspicion: that academic integrity may be compromised. Although the focus area had gradually shifted to students' learning outcomes, the "damage is done" as both sides grapples with incidences of alleged students cheating while perceived loopholes in assessment procedures got plugged with various measures – such as policy guidelines – detailing what are permitted and what are not, regarding GenAI use.

AI technologies will continue to evolve and what seemed like novelty of what it can do today will fast become key elements for work and life. Already appearing over the horizon is Agentic AI, which is an AI system that combines multiple types of artificial intelligence that, together, make it capable of planning, acting, learning, and improving. Agentic AI don't just react or follow preset rules; they can act with autonomy, initiative, and adaptability to pursue goals. This form of AI is capable of independently making decisions and taking actions to fulfill objectives in dynamic environments (UiPath, n.d.)

The model shared in this paper presents an approach that equips faculty with a pedagogical basis to explain to students why they did what they did, how students can better transit to the working world rife with AI usage; as they had retained the "core" of human trait that sets us apart from machines, however smart the machines were designed to be. How it will fare when pitted against Agentic AI is not known. As it stands, we hope our model will provide us with a process-oriented compass to navigate the complexity of AI in education, which will no doubt gets even more complex in the near future; while attempting to preserve the human cognitive core. "The truth is out there" as the famous tagline from the TV-series The X-Files goes. That makes it all the more important to build trust with our own students in our journey in education using AI.

ACKNOWLEDGEMENTS

The author received no financial support for this work.

Full Disclosure: The following sections of this paper made use of GenAI (Copilot): Discussion on consideration of pedagogy as cognitive manifestation, exploration of what elements of human capacities constitute "the core" and the resultant Table 1. The full document – prompts and responses – is available from the following link in the PDF file marked "103". https://drive.google.com/drive/folders/1h5gPaRxba899Yjk2GbR5JqJ4jeeqMqLo?usp=sharing

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