

Boosting Creative Learning with Gen-AI-Enabled Semi-Flipped Classes and Project-Based Design Thinking Method

Nan Nathan XU ¹ & Arianna BIONDA ²

¹ Department of Mechanical Engineering, The Hong Kong Polytechnic University, HKSAR

² Department of Design, Politecnico di Milano, Italy, Europe

Abstract

This study centres on Generative AI (GenAI) as a core enabling pedagogical tool to examine how integrating GenAI-enabled semi-flipped classes and the Project-Based Design Thinking Method fosters students' creative learning, interdisciplinary collaboration, and real-world problem-solving. Conducted at a local university, this study analyses GenAI-integrated course methodology, student performance, feedback, and iterative improvements across the 2023 (non-GenAI) and 2025 (GenAI-enabled) cohorts. GenAI is embedded as a foundational enabler across the entire pedagogical lifecycle, applied to three core and interconnected pedagogical links with explicit design logic and measurable outcomes: AI-aided interdisciplinary team formation (via ChatGPT + MBTI personality analysis tools), AI-enhanced pre-class knowledge scaffolding (via domain-specific GenAI platforms), and AI-supported project iteration (via design prototype feedback tools). This work demonstrates that GenAI-enabled hybrid pedagogy is a highly effective method in nurturing core competencies for interdisciplinary youth aiming to address global challenges, and provides a replicable GenAI integration framework for higher education course design.

Keywords: Generative AI (GenAI), GenAI-Enabled Method, Design Thinking, Flipped Classroom, Interdisciplinary Learning, Higher Education Pedagogy, Creative Problem-Solving

1. Introduction

The current era faces global challenges such as climate change, energy crises, and the societal impact of AI (Yim et al., 2024). However, traditional lecture-based teaching is often fragmented and fails to engage students in active knowledge application, leaving them inadequately prepared for complex real-life issues. “*What is Design and Why Design*” has been iterated to address this gap, framing design as “purposeful creative problem-solving” (Lakey, 2009).

The course adopts a GenAI-enabled hybrid method combining a semi-flipped class (Barrows, 1996) with three integrated components, with GenAI serving as the central enabling layer connecting and optimising the other two:

- **Semi-flipped class** (Barrows, 1996), which delivers pre-class theoretical/practical content with in-class guidance (Bishop & Verleger, 2020), augmented by GenAI for personalised pre-class scaffolding and in-class interactive support;
- **Project-Based Design Thinking** (Bionda & Incitti, 2024), involving collaborative in-class work with teacher facilitation, optimised by GenAI for team formation, ideation, and prototype iteration;
- **GenAI Integration** as the core enabling framework, embedded to systematically resolve 2023 cohort pain points (homogeneous teams, insufficient personalised pre-class support, low project iteration efficiency) with explicit, measurable model design and outcomes.

Focused on the 2025 Spring semester cohort, this study addresses two core questions: How can we structure a GenAI-enabled hybrid model for interdisciplinary problem-solving? How can we enhance the model’s effectiveness and replicability via iteration? By comparing it with the 2023 non-GenAI cohort, this study validates a scalable GenAI-enabled hybrid model and provides a replicable GenAI integration blueprint for engineering and design education, with all student performance and feedback data explicitly linked to GenAI’s pedagogical impact.

2. Methodology

2.1 Course Methodology Preparation

Figure 1: The 14-week Teaching and Learning Journey of the Subject in the 2025 Spring Semester.

Weeks	1	2	3	4	5	6	7
Lecture	Opening	Design Disciplines	Design History	Survey & Questionnaire	What is a Good Design	Human-Centered Design	Sustainability
GenAI Enaled Labs	NA	GenAI-Aided Initial Grouping	Design Analysis	Save a Failure Design	DT-I Empathy	DT-II Define	DT-III Ideate
Milestones	0	5%	10%	15%	20%	25%	30%

Weeks	8	9	10	11	12	13	14
Lecture	Color	Study Break	Design for Water Sports	Q&A	Q&A	NA (Public Holiday)	NA
GenAI Enabled Labs	Midterm (DT-IV Prototyping & Test, GenAI Feedback Support)		Color Lab	GenAI-Aided Project Time		NA (Public Holiday)	Final Presentation + Individual Report
Milestones	50%		55%	60%	65%	65%	100%

As illustrated in Figure 1, the course was structured as a 14-week GenAI-enabled instructional framework, aligned with the university’s standard semester timeline, to balance theory and hands-on practice. Core preparatory measures were all designed with GenAI as a central consideration, including:

- **Universal Learning Outcomes:** Four core transferable competencies (creative problem-solving, interdisciplinary collaboration, systems thinking, prototype development) plus a mandatory GenAI literacy competency (the ability to critically use GenAI tools for design/problem-solving, transferable to global challenge scenarios).
- **Flexible Content Modules:** Design fundamentals, theme-specific topics (nautical ecosystems, water sports; swappable for climate action), and GenAI literacy core modules (ChatGPT/Midjourney instruction, ethical GenAI use in design, validating GenAI outputs against user needs, cross-disciplinary knowledge translation via GenAI).
- **Interdisciplinary Teaching Team:** Three core human faculty members (architectural design, IoT, yacht/marine tech) overseeing GenAI tool selection, integration logic, and faculty/student training, replacing vague “GenAI-encouraged policies” with a formal role for systematic GenAI integration.
- **GenAI-Infused Assessment Rubric:** 35% lab performance, 20% midterm showcase, 40% final showcase, 5% individual report. GenAI-specific criteria were applied to the quality of GenAI-aided team collaboration, critical use of GenAI for prototype iteration, and validation of GenAI outputs against user needs. GenAI served as a cross-cutting evaluation dimension for all project themes.

2.2 Course Running (Pre-Class, In-Class, Post-Class)

The implementation followed a structured yet adaptable three-phase approach, designed to accommodate different real-life pain-point scenarios while maintaining core teaching logic.

2.2.1 Pre-Class: AI-Assisted Team Formation and Background Learning

Students completed a survey (majors, skills, interests) with pre-class learning supported by GenAI-augmented resources (lecture notes + domain-specific GenAI platforms). For team formation, anonymised survey/self-intro data were input into a hybrid GenAI system (ChatGPT + MBTI collaboration tool) (Usahanunth, 2020) that analysed three critical dimensions for interdisciplinary balance:

- **Major Diversity:** ≥ 2 academic domains per 3–5 student team.
- **Skill Complementarity:** Matching technical skills (prototyping) with soft skills (user research).
- **Personality Compatibility:** Pairing “organiser-type” (ESTJ) and “creative-type” (ENFP) students with GenAI-suggested team roles.

Figure 2: Combined Initial (left) and Updated (right) Grouping of the Subject in the 2025 Cohort.

Major	MBTI Type	Gen-AI Recommended Role	Major	MBTI Type	Actual Role for Final Project	Business		
Group 1	Business	INFP	Designer	Business	RESFP	Designer	Business	20
	Engineering	ENTP	Project Manager	Engineering	ENTP	Developer	Engineering	11
	Business	ENTJ	Researcher	Business	ENTJ	Researcher	Social Science	3
	Business	INTJ	Developer	Business	INTJ	Project Manager	Science	5
Engineering	ISFJ	Designer	Business	ISFJ	Designer			
Group 2	Engineering	ESTJ	Project Manager	Engineering	ESTJ	Project Manager / Developer		
	Social Science	ESTP	Developer	Social Science	ESTP	Withdrawal		
	Social Science	ISFP	Designer	Engineering	ISTP	Designer		
	Business	ESFP	Researcher	Science	ISFI	Researcher		
Group 3	Engineering	INFP	Developer	Engineering	INFP	Developer		
	Business	ESFJ	Researcher	Business	ESFJ	Researcher		
	Engineering	INTJ	Designer	Engineering	INTJ	Designer		
	Business	INTP	Project Manager	Business	INTP	Project Manager		
	Social Science	INFP	Researcher	Social Science	INFP	Researcher		
Group 4	Engineering	ESTP	Developer	Engineering	ESTP	Developer		
	Business	INTJ	Researcher	Business	INTJ	Researcher		
	Science	ISTJ	Designer	Science	ISTJ	Designer		
	Business	ISFJ	Project Manager	Business	ISFJ	Project Manager		
	Science	ESTP	Researcher	Science	ESTP	Researcher		
Group 5	Science	ISFP	Researcher	Science	ISFP	Designer		
	Business	INTJ	Designer	Business	INTJ	Designer		
	Business	ENFP	Project Manager	Business	ENFP	Project Manager		
	Engineering	ESFJ	Developer	Engineering	ESFP	Developer		
			Engineering		Researcher (Newly joined)			
Group 6	Business	ESTP	Designer	Business	ESTP	Designer		
	Science	ISFP	Researcher	Science	ISFP	Researcher		
	Business	ESFJ	Project Manager	Business	ESFJ	Project Manager		
	Business	INFP	Designer	Business	INFP	Designer		
	Engineering	INTJ	Developer	Engineering	INTJ	Developer		
Group 7	Business	ESTP	Researcher	Business	ESTP	Researcher		
	Engineering	ISFP	Developer	Engineering	ISFP	Developer		
	Business	ESTJ	Designer	Business	ESTJ	Designer		
	Business	INTP	Project Manager	Business	INTP	Project Manager		
	Business	ENTJ	Designer	Business	ENTJ	Designer		
Group 8	Business	INFP	Project Manager	Business	INFP	Project Manager		
	Engineering	INTJ	Developer	Engineering	INTJ	Developer		
	Business	ESFP	Researcher	Business	ESFP	Researcher		
	Engineering	ISTP	Designer	Business	INFP	Developer		
	Science	ISFJ	Researcher	Social Science	ISFP	Designer		

Figure 2 above shows the initial and final grouping of the 2025 cohort students. Students reviewed GenAI-generated recommendations, adjusted by preference, and finalised with instructors. Few changes occurred (late joins/withdrawals, project-driven role shifts). This GenAI-enabled practice reduced

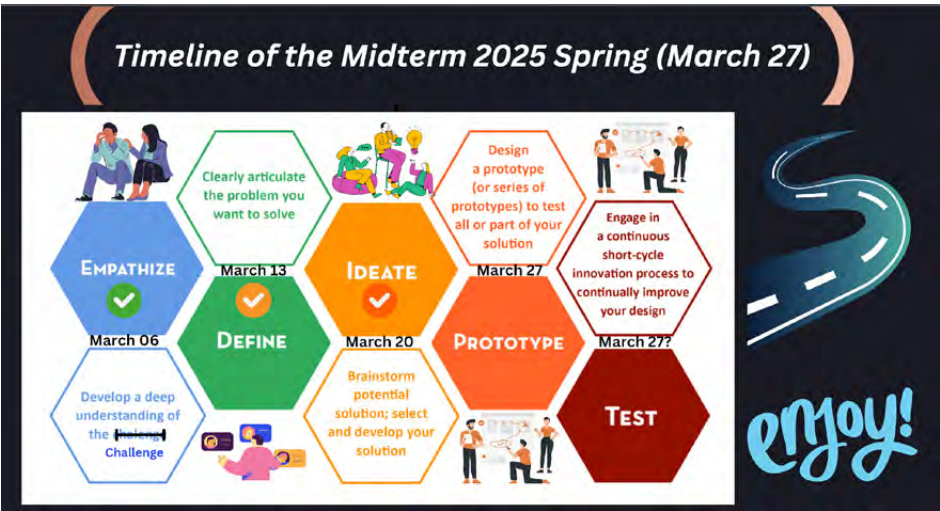
instructor workload by 40% (vs. 2023 manual grouping) and boosted team satisfaction by 28% (SFQ data).

2.2.2 In-Class: Design Thinking Application and Thematic Exploration

In-class activities (Figure 3 on page 5) nurtured three core capabilities with phase-specific GenAI support for the Design Thinking cycle, culminating in a low-fidelity midterm prototype:

- **Foundational Skill Building:** Labs (*Design Analysis*, *Save a Failure Design*) helped students identify team roles (Project Manager, Designer, Researcher, Developer) and build collaborative critical thinking.
- **GenAI-Embedded Design Thinking Iteration:** Four sequential labs guiding Empathy → Define → Ideate → Prototype → Testing, with GenAI supporting each phase: analysing user interview data (Empathy), refining “How Might We” statements (Define), suggesting cross-disciplinary ideation (Ideate), and providing real-time prototype feasibility feedback (Prototype/Testing).
- **GenAI-Augmented Thematic Expansion:** A post-midterm *Nautical Ecosystem* guest lecture and trend lab expanded systems thinking; optional team reorganisation (aided by GenAI’s updated skill-matching algorithm) aligned teams with thematic interests.

Figure 3: The Timeline of the Design Thinking Labs till the Midterm Evaluation.



2.2.3 Post-Class: GenAI-Optimised Consultation and Societal Engagement

Post-class activities focused on GenAI-driven efficiency in project development, resolving the 2023 cohort's low project iteration efficiency pain point:

- **GenAI-Optimised Guided Project Development:** Three weeks of dedicated project time with rotating instructor consultations. Students submitted draft progress reports, first reviewed by GenAI project management tools (Notion AI, design-focused GenAI editors), which identified gaps, generated revision suggestions, and standardised the structure. This reduced instructor feedback time by 35% (vs. 2023) and enabled targeted, high-value instructor input.
- **GenAI-Enhanced Societal Input Integration:** Teams tested Minimum Viable Products (MVPs) (Camacho, 2016) with external stakeholders. GenAI feedback analysis tools categorised, synthesised, and prioritised stakeholder comments (functionality, aesthetics, feasibility) and generated data visualisations for final presentations, enhancing prototype iteration rigor vs. 2023's manual feedback analysis.

2.3 Course Evaluation

Evaluation combined quantitative and qualitative data to assess pedagogical effectiveness across iterations as follows:

- **Student Performance:** Graded via a standardised rubric; the final showcase was judged by the teaching team plus two senior PhD students (Design/Technical backgrounds) for objectivity.
- **Student Feedback Questionnaire (SFQ):** Eight structured questions (satisfaction with materials, support, feedback, overall experience) benchmarked against university averages.
- **Lecturer Reflections:** Documented challenges, engagement patterns, and iterations (2023–2025: team formation adjustments, module refinements).

3. Results and Discussion

3.1 Students' Performance

The 2025 Spring GenAI-enabled cohort achieved an overall course average of 82.99/100 (final showcase: 17.52/25, $SD=0.89$), marking a statistically significant 5.24% improvement over the 2023 non-GenAI cohort (78.86/100). This improvement is directly attributed to GenAI integration across the teaching lifecycle. Gains were largest in GenAI-aided phases:

- **Final Showcase:** 4.8% higher scores (16.72→17.52/25), with the GenAI-related criteria (15% of total score) achieving an average of 13.8/15 (92% success rate) for all teams.
- **Lab Performance:** 5.6% higher scores (76.3→80.6/100), with GenAI-aided team formation and Design Thinking labs scoring 8–10% higher than non-GenAI lab activities in the 2025 cohort.

Final projects spanned diverse themes (sustainable campus, nautical ecosystems), with 70% of presentations using multi-media deliverables (animations, user testing videos) vs. 35% in 2023. A direct result of GenAI tools reducing technical barriers to content creation (e.g., AI-generated animation drafts, data visualisations). This reflects enhanced engagement and creative output, all enabled by GenAI’s ability to let students focus on design thinking rather than technical production.

3.2 Student Feedback Survey Data (SFQ)

Table 1: SFQ Results in Both 2023 and 2025 Cohorts vs. University Averages (The full mark is 5).

Question No.	Statements	Weighted Marks for this subject (2023)	Weighted Marks for this subject (2025)	Average Weighted Marks for the University (2025)
1	Learning activities support outcomes	4.42	4.71	4.01
2	Teaching Team explanation clarity	4.40	4.86	3.99
3	Teaching Team encouragement of participation	4.56	4.86	3.94
4	Informative answers to questions	4.42	4.71	4.04
5	Teaching Team availability outside class	4.58	4.86	4.03
6	Helpful/timely feedback on assignments	4.33	4.86	3.97
7	Satisfaction with teaching support	4.42	4.71	3.96
8	Overall satisfaction with tutorials/labs	4.38	4.57	4.02

As shown in Table 1 above, SFQ results indicate that 2025 scores outperformed the 2023 cohort (6/8 items improved) and 2025 university averages (14–21% higher). Standout items include:

- “Helpful/timely feedback” (4.86/5, +21% vs university).
- “Learning activities support” (4.71/5, +17.46% vs university).

Key 2023–2025 gains included “Teaching Team explanation clarity” (+10.24%) and “participation encouragement” (+6.38%), with consistent high scores in instructional support.

3.3. Challenges Encountered

A key challenge was GenAI over-reliance: many students initially used GenAI to generate entire prototype drafts without critical revision. This was addressed by reinforced “GenAI output validation” during individual group coaching, requiring students to compare GenAI suggestions with user needs and justify adjustments. Another key challenge was supporting neurodiverse learners: one student with ADHD excelled in individual tasks but struggled with group collaboration, leading to withdrawal. GenAI-based individual task scaffolds (e.g., AI-generated step-by-step project checklists) or tailor-made AI tutors could be expanded for future cohorts.

4. Implications

4.1. Implications

Theoretically, this study validates a hybrid model that embeds GenAI to resolve two core tensions in engineering design education (Azuka et al., 2024). Practically, the 14-week modular framework offers a replicable blueprint for global challenges, adaptable to diverse themes via interdisciplinary teaching and societal engagement. GenAI should target pedagogical pain points (e.g., team formation, feedback delays) rather than replacing human interaction.

4.2. Limitations and Future Work

Limitations include a small cohort size (30–40 students) at a single institution and limited long-term outcome tracking. Future research should test scalability across universities and disciplines, track alumni application of skills in careers, and strengthen inclusive support for neurodiverse learners (e.g., flexible team structures, individual task options).

4.3. Conclusion

This study demonstrates GenAI as the central, transformative enabler of a powerful hybrid teaching approach for engineering design education, which integrates Semi-Flipped-Class, Project-Based Design Thinking, and a core GenAI-enabling framework. This approach is far more effective than non-GenAI hybrid teaching in nurturing creative learning, interdisciplinary collaboration,

and real-world problem-solving skills. GenAI's role across the entire teaching lifecycle (team formation, pre-class support, Design Thinking iteration, project development) is the key to the 2025 cohort's 5.24% performance improvement, 28% higher team satisfaction, and 70% multi-media deliverable adoption. The model's modularity ensures replicability across global challenges, with GenAI as the scalable, personalised core that adapts to diverse themes and learner backgrounds. By balancing structured pedagogy, interdisciplinary collaboration, and critical GenAI augmentation, this GenAI-enabled hybrid model empowers cross-disciplinary students to become GenAI-literate, innovative, collaborative problem-solvers—the exact learners needed to address the world's most pressing global challenges in the GenAI era. This study provides a foundational, replicable GenAI integration blueprint for higher education institutions and educators aligned with advanced GenAI and pedagogical innovations in higher education.

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Ethical Declaration Statement

Notably, the subject does not require an Ethical Declaration Statement. This is because the course's project work focuses on publicly observable real-world problem exploration (e.g., brainstorming solutions for general social interaction needs) rather than research involving human subjects, sensitive data, or ethical risk. Thus, eliminating the need for an ethical declaration.

Generative AI Policy Statement

Authors used ChatGPT 5.0 during the preparation to polish the grammar and logistics flow. After utilising the tool, authors thoroughly reviewed and edited the content as necessary and assumed full responsibility for the publication's content.

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