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Beyond Deterministic Design: Engineering Education for AI-Enabled Heterogeneous Systems

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ABSTRACT

As generative artificial intelligence (AI) automates engineering design, a fundamental reconceptualization of engineering education becomes necessary. This constructive position paper proposes the "vibe-designer"—a new professional paradigm that strategically compresses the traditional middle phase of the engineering curriculum to focus on high-level specification, adversarial evaluation, and systemic contextualization. Drawing on Floridi's philosophy of information and Simondon's theory of technical individuation, we argue that the future of engineering lies in the orchestration of conceptual frameworks, ethical stewardship of artificial agents, and "generative judgment"—the capacity to evaluate and contextualize machine-generated solutions within complex sociotechnical systems. We situate this paradigm explicitly within the context of next-generation heterogeneous engineered systems—including cognitive-cyber-physical-social-human (CCPSH) systems, AI-enabled agentic systems-of-systems, and multi-constituent platforms integrating hardware, software, cyberware, and brainware—that constitute the primary site of contemporary systems engineering practice. Central to our argument is the transformation from individual to collaborative creation: creativity in the AI era emerges from dialogical interaction between human intentionality and machine capability. We present a comprehensive curricular architecture based on a transdisciplinary approach, explore epistemic implications, and address critical challenges including the verification gap, liability frameworks, and the preservation of embodied technical intuition. To concretely illustrate the proposed approach, the authors present a hypothetical case study grounded in realistic engineering constraints and current AI capabilities. As a

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constructive position paper, it aims to provide a foundation for pilot programs and systematic empirical investigation—and to open a space for argument about where engineering education must go next.

Keywords: Engineering Education; Transdisciplinary Education; Higher Education; Generative AI; Cognitive-Cyber-Physical-Social-Human Systems; Paradigm Shift

1. Introduction

The classical engineering curriculum is comprised of three tiers. The lower stage provides in-depth knowledge in mathematics, computer science, and relevant natural sciences. The middle phase consists of basic engineering courses that focus on a relatively low level of abstraction (LoA) and enable the graduate to perform engineering design. The upper tier of the program includes advanced courses at a relatively high LoA dealing with systems analysis [1, 2].

Inspired by the historical specialization of the Renaissance polymath into distinct theorist and experimentalist roles [3], the article proposes a new technological profession, *vibe-designer*. Students in the proposed program will study the lower and upper tiers (with modifications) of the classical engineering curriculum, omitting the middle stage. Consequently, graduates of the program will not have the ability to perform engineering design. Instead, they will focus on systems analysis while adopting a transdisciplinary approach [4]. At the heart of this novel paradigm is the desire to free vibe-designers from dealing with details and to allow them to focus on the big picture while taking into account various considerations, such as economic, environmental, social, ethical, etc.

The authors believe that through AI, the conditions are ripe for the implementation of the new paradigm in education. Similar to the vibe-coding approach [5], the vibe-designer will describe, in natural language, an engineering system to AI. The vibe-designer will then analyze the system generated by the AI and check, among other things, that it meets the established requirement (**Figure 1**).

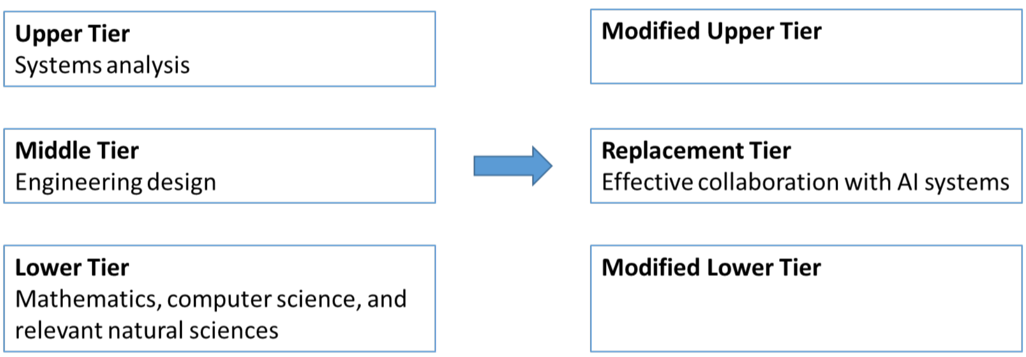

Figure 1. Classical engineering curriculum (left) vs. vibe-designer curriculum (right).

Note: The middle tier is strategically compressed and AI-delegated; retained tiers are augmented with new competencies.

Based on philosophical foundations, namely, Floridi's philosophy of information [6, 7] and Simondon's philosophy of technology [8], this constructive position paper proposes a comprehensive curriculum for vibe-designers, explores epistemic implications, and addresses relevant challenges. The paper does not provide empirical results. However, to illustrate the proposed approach, we present a hypothetical case study, namely, an adaptive neighborhood energy grid grounded in realistic engineering constraints and current AI capabilities.

The vibe-designer paradigm is not intended as a generic response to AI automation in the abstract. Rather, it is motivated by and addressed to a specific class of engineering systems, namely next-generation heterogeneous engineered systems—systems that are simultaneously cognitive, cyber, physical, social, and human-constituted (CCPSH). These systems are characterized by: (i) a multi-constituent architecture integrating hardware (physical infrastructure), software (computational layers), cyberware (components that integrate directly with the human nervous system), and brainware (the cognitive layer of human actors embedded in the system—their expertise, judgment, and organizational roles); (ii) AI enablement at the agentic (AAI), generative (GAI), predictive (PAI), or explainable (EAI) level, producing emergent behaviors not deducible from subsystem specifications; (iii) embeddedness in social, institutional, and environmental contexts that generate non-technical requirements and constraints; and (iv) the need for transdisciplinary or post-disciplinary educational approaches.

The adaptive neighborhood energy grid mentioned above is an illustrative instance of such a system. It combines physical infrastructure, networked software agents, institutional contracts between human actors, and social dynamics of participation—precisely the multi-constituent, socio-technically embedded character that defines the class. The claim of this paper is that the vibe-designer, as we define the role, is the appropriate professional formation for engineers who will develop, specify, and oversee this class of systems.

In genre, this article is a constructive position paper—a paper type well established in engineering education research (see, e.g., Özkan et al.[9]). As such, it goes beyond analyzing the existing engineering curriculum model to propose an innovative and forward-looking technological profession. In other words, the paper does not settle for analyzing the issue at hand but rather proposes a new course of action, namely, a curricular and professional reorganization of engineering education in response to the displacement of the design tier by generative AI.

2. The Classical Engineering Curriculum and Its Historical Epistemology

The classical engineering curriculum embodies an epistemological architecture that has remained remarkably stable since the formalization of engineering education in the nineteenth century[1, 2]. This tripartite structure reflects deep assumptions about the nature of technical knowledge and its acquisition—assumptions that generative AI now fundamentally challenges.

Here, the term “classical curriculum” is used as a Weberian ideal type—a structural logic dominant in major accreditation frameworks such as the Accreditation Board for Engineering and Technology (ABET), the European Network for Accreditation of Engineering Education (ENAEE), and the Conceive–Design–Implement–Operate (CDIO) initiative—without implying that every existing program follows it exactly. Engineering education in practice covers a wide spectrum of disciplines and institutional configurations; our critique of this dominant logic applies with varying intensity across fields and contexts.

The lower tier of the curriculum provides deep knowledge in mathematics, computer science, and natural sciences. This foundation serves multiple functions: it establishes a common technical vocabulary, develops analytical thinking capacities, and—critically—creates what Polanyi termed “subsidiary awareness”: tacit knowledge that enables practitioners to recognize when something “feels wrong” in a design[10]. The mathematics of calculus, linear algebra, and differential equations does not merely provide computational tools. It shapes the engineer’s cognitive understanding of change, relationships, and constraints. This tier also serves a critical sociological function: it creates shared epistemic standards within the profession. When engineers debate a design decision, they can appeal to mathematical first principles as a common adjudicatory framework. The question confronting engineering education is whether AI mediation preserves or erodes this shared epistemic foundation.

The middle phase—core engineering courses focused on low LoAs—has historically served as the crucible in which theoretical knowledge transforms into practical capability. Through iterative exercises in circuit design, structural analysis, thermodynamic calculations, and code implementation, students develop what Dreyfus termed “skillful coping”: the ability to respond appropriately to technical situations without explicit rule-following[11]. This phase embodies what Schön characterized as “reflection-in-action”—the capacity to think while doing, adjusting approach based on immediate feedback[12]. The engineering student who debugs code, recalculates beam parameters, or iteratively refines a circuit design develops not merely procedural knowledge but embodied expertise—enabling pattern recognition, anomaly detection, and opportunity identification. The critical question is whether this embodied expertise can be preserved when implementation is delegated to AI systems, or whether some essential cognitive-practical integration is thereby lost.

The upper tier addresses systems thinking: understanding how components interact, how designs propagate through organizational and social contexts, and how technical decisions are embedded within broader value frameworks [13]. This tier has always been somewhat marginalized in traditional curricula, treated as a capstone rather than a core competency.

We argue that the advent of generative AI inverts this hierarchy. When implementation becomes increasingly automated, the capacity for systemic judgment—understanding context, stakeholders, values, and unintended consequences—becomes the primary locus of human contribution.

The transformation we describe builds on, but is distinct from, three adjacent bodies of literature. Research on AI-assisted engineering design productivity gains achievable when engineers use AI tools within existing workflows [14, 15]; our argument is that this tool-adoption framing understates the structural shift underway. Model-based systems engineering (MBSE) has moved practice toward formal specification and system-level abstraction [16]—a trajectory the vibe-designer paradigm extends by replacing formal specification with natural-language dialogue with generative AI. Engineering competency frameworks such as ABET, ENAEE and CDIO define professional formation in terms of the full tripartite curriculum [1, 2]; our proposal challenges this assumption, arguing that the middle tier's role is partially transferable to AI systems at sufficient capability levels [17, 18]. The vibe-designer is not a redescription of the systems engineer, the AI prompt engineer, or the MBSE practitioner—it is a new professional formation that none of these frameworks anticipates.

3. Historical Precedent: Specialization as a Technological Response

The relationship between technological capability and professional structure is not deterministic, but it exhibits recognizable patterns [19]. New technologies do not simply automate existing tasks; they restructure the division of cognitive labor, creating new specializations while dissolving others. The printing press did not merely speed up manuscript copying—it enabled the separation of authorship from reproduction, eventually giving rise to distinct professions of writing, editing, typesetting, and publishing. Similarly, the development of CAD systems did not simply accelerate drafting—it restructured the relationship between conceptual design and technical drawing, eventually enabling forms of parametric design that would have been inconceivable in the era of manual drafting.

Understanding these patterns provides insight into the likely trajectory of engineering practice under generative AI. We identify two major historical transitions that illuminate the current moment: the Renaissance integration of theory and craft and the subsequent specialization that separated them. A third transition—the separation of specification from implementation—is now underway.

3.1. Renaissance Integration

The Renaissance polymath—one who masters multiple disciplines, exemplified by Leonardo da Vinci, but also Brunelleschi, Alberti, and others—embodied a unity of theory and craft that seems almost inconceivable today [3]. Leonardo did not merely design flying machines; he dissected birds, studied air currents, experimented with materials, and built prototypes with his own hands. His notebooks reveal an epistemology in which knowing and doing were inseparable.

This integration was enabled by technological constraints: the pace of knowledge production was slow enough, and the technical tools simple enough, that a single individual could maintain competence across the full span from principle to implementation. The guild system reinforced this integration, requiring masters to have passed through all stages of craft production [20].

3.2. The First Great Specialization: Theory and Experiment

The Scientific Revolution of the seventeenth century initiated what we term the First Great Specialization [21]. The increasing complexity of both theoretical frameworks and experimental apparatus made the ambition to master multiple disciplines increasingly untenable. Natural philosophers like Newton and Leibniz focused on mathematical formalization, while instrument-makers like Robert Hooke and Antonie van Leeuwenhoek developed the material technologies that enabled new observations.

Critically, this specialization was enabled by new coordination technologies—principally the printing press and the emergence of scientific societies. The Royal Society and the Académie des Sciences provided institutional frameworks for managing the interface between theoretical and experimental work. The scientific journal emerged as a technology for transmitting results across the specialization boundary [21].

The parallel to our moment is instructive: just as the printing press enabled a new division of cognitive labor by providing reliable knowledge transmission, generative AI enables a new division by providing reliable implementation. The "prompt" becomes analogous to the "paper"—a formalized interface for coordinating specialized activities.

3.3. The Second Great Specialization: Specification and Implementation

We argue that generative AI initiates a Second Great Specialization [22–24]. Just as the first specialization divided theoretical understanding from experimental realization, this second specialization divides system specification from technical implementation. The human engineer increasingly operates at the level of requirements, constraints, and evaluation criteria, while AI systems handle the translation of those specifications into concrete designs.

This parallel illuminates both opportunities and risks. The First Great Specialization enabled unprecedented scientific progress but also created communication gaps, coordination failures, and periodic crises of integration. We should expect analogous dynamics in the Second Great Specialization: dramatic productivity gains accompanied by new forms of misunderstanding, new failure modes at the human-AI interface, and periodic crises when AI capabilities outpace human evaluative frameworks.

It is important to note that as a result of the First Great Specialization, the Renaissance polymath was replaced by the theorist and the experimentalist. We claim that in the Second Great Specialization, engineering roles are divided between humans and AI systems. We do not argue, however, that traditional engineers will vanish completely as polymaths did in their time.

A methodological note on the historical analogy is warranted here. We do not claim that the Renaissance-to-Scientific Revolution transition and the present AI transition are similar in their social conditions, timescales, or human costs—they are not. The First Great Specialization unfolded over generations and produced fragmentation and deskilling we do not wish to reproduce. The analogy is structural: in both cases, a new coordination technology made the previously necessary integration of cognitive roles no longer necessary at the individual level, enabling a new division of cognitive labor. The lesson is not that the current transition is inevitable or costless, but that such transitions have precedent and the key challenge is managing the interface between newly separated roles.

4. The Vibe-Designer: Definition, Scope, and Epistemic Position

The vibe-designer represents a fundamentally reconceived engineering role—one that emerges from, rather than despite, the capabilities of generative AI. The term deliberately evokes "vibe-coding" [25], extending its implications across the full spectrum of engineering practice.

4.1. Conceptual Framework

The vibe-designer studies the lower and upper tiers of the classical curriculum while strategically omitting or radically compressing the middle phase (**Figure 1**). This omission is not mere subtraction but a fundamental reorientation of engineering epistemology. The vibe-designer does not perform engineering design in the traditional sense—the iterative, detail-oriented process of translating requirements into specifications and specifications into implementations.

Instead, the vibe-designer focuses on what we call "generative judgment": the capacity to articulate requirements in forms that AI systems can productively interpret, to evaluate AI-generated solutions against multidimensional criteria, and to contextualize technical outputs within complex sociotechnical systems. This judgment operates at the intersection of human intentionality and machine capability.

Generative judgment is analytically distinct from both Dreyfus's "skillful coping"—which is acquired through embodied practice at the implementation level [11]—and from Schön's "reflection-in-action," which presupposes iterative hands-on engagement with material constraints [12]. Generative judgment, by contrast, is exercised at the specification-evaluation interface: it is the capacity to probe, stress-test, and reframe AI-generated outputs without having produced those outputs oneself. Recent empirical work on human-AI oversight confirms that high-quality evaluation of AI outputs requires precisely this capacity, and that it can be cultivated independently of implementation skill [14, 15].

The vibe-designer is formally defined as a next-generation engineering professional who operates exclusively at the specification and evaluation levels of abstraction, relying on generative AI systems for implementation while maintaining full accountability for system-level requirements, constraints, safety, and sociotechnical context. This role is structurally distinct from both the classical engineer (who spans all three curriculum tiers) and the prompt engineer (whose scope is limited to optimizing human–AI dialog).

Crucially, we position the vibe-designer not merely as a "prompt engineer" but as a next-generation lifecycle engineer—a professional responsible for the full arc of system development in CCPSH and agentic system-of-systems contexts: from concept formation and architectural specification, through integration oversight and adversarial audit, to operational monitoring and ethical stewardship. The five core competencies enumerated in Section 4.3 map directly onto these lifecycle phases (see Section 7).

A second point requires direct acknowledgement: critics may object that a practitioner who has not traversed the middle-tier implementation curriculum lacks the domain knowledge to supervise AI-generated designs responsibly. We take this objection seriously. Our response is epistemological rather than dismissive: supervisory competence at the requirement LoA is structurally different from implementation competence at the component LoA. A structural engineer who relies on finite-element solvers does not re-derive the numerical methods; a clinical decision-support professional does not re-train the diagnostic model. What is required is adversarial acuity—the ability to probe, stress-test, and contextualize AI outputs—and a minimum of domain "feel" sufficient for anomaly recognition. The latter is preserved in the vibe-designer curriculum through compressed experiential learning and failure case libraries (see Section 9.3), which retain the embodied intuition-building function of the middle tier in a concentrated, simulator-mediated form.

4.2. The Concept of "Vibe" in Technical Practice

The term "vibe" requires philosophical elaboration. In vibe-coding, a programmer describes desired functionality in natural language and iterates with AI until satisfactory code emerges [25, 26]. The "vibe" refers to this gestalt specification—an articulation of intent that is meaningful to both humans and machines without being fully formalized.

Philosophically, vibe occupies an interesting epistemic position. It is more determinate than a wish but less determinate than a formal specification. It combines denotative content (what the system should do) with connotative dimensions (how it should feel, what values it should embody, what trade-offs are acceptable). Vibe is inherently dialogical—it emerges and refines through interaction between human intent and AI interpretation.

This dialogical quality distinguishes vibe-specification from traditional requirements engineering. In classical practice, requirements should be complete, consistent, and unambiguous before implementation begins [27]. In vibe practice, requirements are provisional. They evolve through interaction with AI-generated possibilities. Specification emerges from generation rather than preceding it.

4.3. Core Competencies of the Vibe-Designer

The vibe-designer must develop several distinctive competencies that differ from traditional engineering abilities:

The first competency is Specification Articulation, i.e., the ability to translate human needs—often vague, contradictory, and context-dependent—into forms that AI systems can productively interpret. This requires not merely technical vocabulary but an understanding of how AI systems interpret and misinterpret human language [28, 29]. Another relevant skill is Generative Evaluation, namely, the capacity to assess AI-generated solutions against criteria that the AI itself cannot fully represent. This includes aesthetic judgment, ethical considerations, social acceptability, long-term sustainability, and alignment with unstated stakeholder values. Adversarial Imagination, i.e., the ability to anticipate failure modes, unintended consequences, and malicious uses, is also needed. This requires what security researchers call "red team thinking"—the capacity to adopt an adversarial perspective toward one's own designs [30].

An important competency is Systemic Contextualization, namely, the capacity to understand how technical solutions propagate through organizational, social, environmental, and political systems. This requires transdisciplinary knowledge spanning engineering, economics, law, sociology, and ethics [13, 31]. Last but not least is Iterative Refinement, the ability to productively engage with AI systems through multiple cycles of generation, evaluation, and re-specification. This requires patience, precision in feedback, and the capacity to recognize when iteration is improving outcomes versus merely churning.

5. The Collaborative Creativity Paradigm: From Individual to Distributed Creation

Central to the vibe-designer paradigm is a fundamental transformation in the nature of technical creativity itself[32, 33]. This transformation—from individual creation to collaborative creation—represents not a diminution of human creative capacity but its reconfiguration into a new mode of generative practice.

5.1. The Individual Creation Model

Traditional engineering education and practice assume what we term "individual creation": the engineer as a solitary creator who conceives, designs, and implements through individual cognitive effort. The iconic image is the programmer hunched over a keyboard, the engineer bent over a drafting table, the inventor alone in the workshop. In this model, creativity is an individual attribute—some engineers are more creative than others, and the task of the discipline is to identify, cultivate, and deploy creative individuals [34]. This model has deep roots in Romantic conceptions of genius and authorship. The creative act is understood as an expression of an individual's vision, and the artifact bears the signature of its creator. Professional identity centers on technical virtuosity—the capacity to produce sophisticated implementations through personal mastery.

The individual creation model also implies a particular temporal structure: the creator first conceives (in imagination), then designs (on paper or screen), then implements (in material or code). Creativity is concentrated at the beginning—in conception; implementation is its faithful execution.

5.2. The Collaborative Creation Model

Generative AI enables—and perhaps necessitates—a shift to "collaborative creation": a model in which creativity emerges from dialogical interaction between human and artificial intelligence [32, 35]. In this model, neither a human nor an AI is the "creator" in the traditional sense. Rather, creative artifacts emerge from a process of mutual provocation, response, and refinement.

The image here is fundamentally different: not a solitary figure at the keyboard but a human in conversation with an AI collaborator, with creative insight—the proverbial lightbulb—emerging in the space between them. The human brings intention, values, contextual understanding, and evaluative judgment. The AI brings vast pattern recognition, rapid generation of alternatives, and exploration of possibility spaces that would exceed human cognitive capacity. Neither contribution alone produces the creative output; it emerges from their interaction.

This model disrupts the temporal structure of individual creation. There is no clean separation between conception, design, and implementation. Instead, the creative process becomes iterative and cyclical: humans articulate intention, AI generates possibilities, humans respond with evaluation and refinement, and AI generates new possibilities informed by that feedback. The creative artifact crystallizes gradually through this dialogue rather than emerging fully formed from individual imagination.

5.3. Precedents in Human Creative Practice

While human-AI creative dialogue is novel, collaborative creation itself has important precedents in human practice [33, 36]:

The first precedent is jazz improvisation. In jazz, creativity emerges from real-time interaction among musicians. No single performer controls the creative output; rather, the music arises from mutual listening, response, and provocation. The jazz musician's skill lies not in solo composition but in collaborative responsiveness. Another example is collaborative screenwriting. Many successful screenplays emerge from writing partnerships where ideas bounce between collaborators, each building on and transforming the other's contributions. The script emerges from dialogical development rather than individual authorship.

Architectural charrettes are also an important precedent. In architectural practice, design charrettes bring together multiple designers for intensive collaborative sessions. The goal is precisely to transcend the limitations of individual conception—to generate ideas that no single architect would produce alone. The last example deals with scientific collaboration. Modern scientific research increasingly operates through large collaborations where individual contributions blur[37]. Discovery emerges from the collective rather than from identifiable individual insight.

These precedents suggest that collaborative creation is not inherently inferior to individual creation—indeed, in many domains, it produces outcomes that individual creation cannot achieve. The shift to human-AI collaborative creation extends this pattern rather than introducing something entirely unprecedented.

5.4. The Space Between: Where Creativity Emerges

The key insight of the collaborative creation model is that creativity inhabits the space between humans and AI in addition to residing in either party individually. This has important implications for how we understand and cultivate creative capacity.

In individual creation, developing creativity means developing the individual—their knowledge, skills, and imaginative capacity. In collaborative creation, developing creativity also means, and more importantly, developing the quality of the interaction—the protocols, languages, and practices through which humans and AI engage. The vibe-designer's creative capacity is not a personal attribute but a relational achievement.

This relational conception of creativity aligns with emerging perspectives in creativity research that emphasize social and distributed cognition[34, 36]. Creativity is increasingly understood not as individual inspiration but as emerging from interactions among people, tools, and environments.

5.5. Implications for Engineering Identity

The shift from individual to collaborative creation has profound implications for professional engineering identity. If creativity is relational rather than individual, what does it mean to be a "creative engineer"? We propose that vibe-designer creativity manifests in three dimensions:

The first dimension is Provocative Articulation, namely, the ability to frame problems and articulate intentions in ways that elicit productive AI responses. The second dimension is Discerning Selection, i.e., the capacity to recognize value in AI-generated possibilities—to identify the unexpected solution that addresses unstated needs, the surprising combination that opens new directions, and the elegant formulation that crystallizes vague intentions. The last dimension, Developmental Iteration, deals with the ability to guide the collaborative process through productive cycles of generation and refinement. These creative capacities are genuine skills that can be developed and refined—they are not merely passive consumption of AI outputs.

5.6. Against the Deskilling Narrative

The collaborative creation paradigm provides a response to perhaps the most persistent critique of the vibe-designer concept: that it represents a "deskilling" of engineering[22], producing practitioners who cannot actually do anything themselves.

This critique assumes that "real" engineering skill consists of implementation capacity. From the individual creation perspective, an engineer who cannot implement is indeed deskilled. But from the collaborative creation perspective, implementation skill is only one form of creative contribution—and not necessarily the most valuable in an era of AI capability. The vibe-designer possesses different but genuine skills: the skill of productive collaboration, the skill of multidimensional evaluation, and the skill of systemic integration.

6. Philosophical Foundations

The vibe-designer paradigm requires philosophical grounding that addresses both the epistemic position of the practitioner and the ontological status of the AI-mediated design process. We draw primarily on Floridi's philosophy of information[6, 7] but supplement it with insights from Simondon's philosophy of technology[8].

Taken together, these two frameworks do not merely provide vocabulary for the vibe-designer's epistemic position—they already presuppose a form of transdisciplinary epistemology. Floridi's Level of Abstraction (LoA) is inherently perspective-relative and system-agnostic: it applies equally to software architectures, cyber-physical systems, and social institutions, dissolving disciplinary boundaries in the act of analysis[6]. Simondon's individuation is irreducibly relational—the technical object exists only through its ongoing co-constitution with the milieu of human practices, organizational structures, and environmental constraints[8]. Both frameworks thus implicitly call for transdisciplinary epistemic synthesis as the appropriate mode of reasoning for complex CCPSH systems, not disciplinary expertise applied sequentially. The vibe-designer curriculum enacts this synthesis structurally by replacing the middle implementation tier with transdisciplinary integration across law, ethics, sociology, and sustainability—disciplines unified not by a common methodology but by a shared object: the sociotechnical system in its full complexity.

Floridi's concept of LoA provides a rigorous framework for understanding the vibe-designer's epistemic position. This concept was already mentioned earlier, and now is formally defined as a collection of observable variables together with associated operators and predicates that constitutes a perspective on a system[6].

This formal definition is the analytical hinge on which the vibe-designer's epistemic position turns. The vibe-designer does not operate at a lower LoA as a deficit—the absence of implementation skills is the structural consequence of working at the requirement LoA, where different observables, operators, and predicates are in play. Floridi's framework thus provides precise technical vocabulary for what might otherwise appear as a merely pragmatic curriculum choice: the compression of the middle tier is an epistemological decision, not an educational shortcut.

The traditional engineer operates primarily at a relatively low LoA, namely, the implementation LoA—the level at which specific components, connections, and calculations are visible. The vibe-designer operates primarily at a relatively high LoA, i.e., the requirement LoA—the level at which needs, constraints, and success criteria are visible, while implementation is treated as a black box. This shift in LoA is not merely a practical convenience but represents a genuine epistemic reorientation. The vibe-designer must develop the observables, operators, and predicates appropriate to the requirement LoA—must learn to "see" the design space in terms of stakeholder needs, value trade-offs, and systemic effects rather than in terms of components and connections.

A complementary concept from Floridi's framework is "semantic capital," which illuminates the vibe-designer's value creation mechanism. Semantic capital refers to meaningful informational structures that enable effective action—the organized knowledge, conceptual frameworks, and interpretive capacities that allow agents to navigate complex environments[7]. Vibe-designers create value by translating between domains of meaning—converting human needs into machine-readable specifications, and conversely, translating machine outputs into humanly meaningful evaluations. They are "semantic engineers" operating at the interface between human and artificial intelligence. This translation work is not mechanical but creative. The vibe-designer must recognize the legitimate concerns behind poorly articulated requirements, identify the implicit assumptions that make AI outputs inappropriate for particular contexts, and craft specifications that guide AI systems toward genuinely useful solutions.

Beyond epistemic positioning, Floridi's framework also addresses the ethical dimension of the vibe-designer's role. As a "human-in-the-loop," the vibe designer bears responsibility for outcomes that neither humans nor AI could achieve independently. This distributed agency creates novel ethical challenges that existing frameworks struggle to address[38]. Floridi introduces the concept of a "moral proxy"—an agent who acts on behalf of others who cannot act for themselves[7]. We extend this: the vibe-designer acts as a moral proxy for the entire sociotechnical system, representing human values in the design process even when those values cannot be fully formalized or communicated to the AI. This proxy role requires what we term "anticipatory ethics"—the capacity to foresee moral consequences before they manifest, to represent stakeholders who are absent (future generations, affected communities, the natural environment), and to exercise judgment in situations where formal rules provide insufficient guidance.

Simondon's philosophy of technology offers a complementary perspective, grounding the vibe-designer's role in the dynamics of technical change itself. Simondon argued that technical objects undergo a process of "individuation"—they become more integrated, more internally coherent, and more adapted to their environments over time [8]. In AI-mediated design, this individuation process is dramatically accelerated. AI systems can explore vast design spaces, identifying configurations that human designers would never have considered. The vibe-designer's role is to guide this individuation by shaping the "selection environment"—determining which AI-generated possibilities survive and which are discarded.

Simondon also emphasized the importance of the "associated milieu"—the environment that a technical object creates for itself and which sustains its operation [8]. The vibe-designer must consider not just the technical object in isolation but the associated milieu it will create: the practices, expectations, and dependencies that will emerge around it. This is not a metaphorical application of Simondon but a precise analytical claim: the vibe-designer curriculum omits the middle implementation tier precisely because the associated milieu of CCPSH systems cannot be specified from within the implementation LoA. Only from the requirement LoA, where the milieu itself is a visible observable, can the vibe-designer perform the integrative oversight that such systems demand.

7. Curricular Architecture: Replacing the "Missing Middle"

The vibe-designer curriculum represents a radical departure from traditional engineering education [1, 2]. Rather than treating the omission of core design courses as a deficit, we reconceptualize the curriculum around the distinctive competencies that AI cannot replicate.

7.1. Modified Lower Tier: Modeling and Information Theory

The lower tier retains rigorous mathematics, logic, and natural science but reorients toward capacities that support requirement-level reasoning:

- Mathematical Modeling: The emphasis shifts from calculation to representation. Students learn to construct formal models that capture the essential structure of problems, with less emphasis on manually solving equations.
- Information Theory and Complexity: Students develop a rigorous understanding of information, entropy, and computational complexity. This provides the foundation for understanding AI capabilities and limitations.
- Topology and Relational Thinking: Rather than the geometry of specific shapes, students study the mathematics of relationships and transformations.
- Probability and Statistical Reasoning: A deep understanding of uncertainty, inference, and probabilistic reasoning becomes essential for evaluating AI outputs.

7.2. Replacement Phase: Governance, Verification, and Collaborative Creation

The traditional "core design" phase (typically years 2–3) is replaced with courses focused on human-AI collaboration, adversarial evaluation, systemic governance, and the cultivation of collaborative creativity:

- Prompt Engineering and Specification Languages: Students learn to articulate requirements in forms that AI systems can productively interpret [28, 29]. This includes natural language prompting, formal specification languages, and hybrid approaches.
- Latent Space Navigation: Students develop an understanding of how generative AI systems represent possibility spaces [39]. They learn to strategically navigate these spaces.
- Collaborative Creation Studios: Project-based courses where students engage in extended human-AI creative collaborations.
- Adversarial Audit Labs: Students learn to "red team" AI designs—to systematically search for flaws, failure modes, and unintended consequences [30].
- Human-AI Collaboration Methodology: Students study the dynamics of effective collaboration with AI systems [40].
- Verification and Validation Frameworks: Students learn systematic approaches to verifying that AI-generated designs meet requirements [41].

In addition, the proposed curriculum comprises introductory courses in various engineering fields (e.g., civil, mechanical, electrical, chemical, biomedical, etc.) as well as introductory courses in the social sciences and humanities (e.g., economics, law, psychology, sociology, philosophy, ethics, etc.). The goal here is to provide a solid multidisciplinary foundation for the transdisciplinary education offered at the next tier.

7.3. Expanded Upper Tier: Transdisciplinary Integration

The upper tier expands to include competencies traditionally considered outside engineering:

- Complexity Science and Systems Thinking: Deep engagement with complexity theory, emergence, feedback dynamics, and adaptive systems [13].
- Technology Law and Policy: Understanding regulatory frameworks, liability structures, and the interplay between technical design and legal accountability [42].
- Engineering Ethics and Value-Sensitive Design: Systematic approaches to stakeholder identification, value elicitation, and the design of systems that embody appropriate value trade-offs [38, 43].
- Sociology of Technology: Understanding how technologies are adopted, adapted, and resisted by social groups [19].
- Environmental Assessment and Sustainability: Rigorous frameworks for evaluating environmental impact, including life cycle analysis, carbon accounting, and ecosystem effects.

The Vibe-designer curriculum is presented in **Table 1**. The curriculum is structured not as a juxtaposition of disciplines but as a transdisciplinary epistemic synthesis. The lower tier establishes the mathematical and computational substrate shared across all engineering domains. The replacement tier introduces the vibe-designer's distinctive mode of practice—specification articulation, collaborative generation, and adversarial evaluation—oriented from the outset toward AI-enabled heterogeneous systems. The upper tier then achieves synthesis: complexity science, systems engineering, law, ethics, sociology, and environmental engineering are unified not by a common disciplinary methodology but by a shared object of inquiry—the CCPSH system in its full institutional and environmental embedding. The lifecycle phase column makes this synthesis operational: each curricular element is anchored to a specific phase of CCPSH system development, ensuring that transdisciplinary integration is not merely aspirational but structurally enforced by the program architecture.

An important institutional consideration is the compatibility of this curriculum with existing accreditation frameworks. Engineering accreditation bodies—including ABET and ENAEE—currently require demonstrated competency in hands-on engineering design, the very phase that the vibe-designer curriculum strategically compresses. A program built on this model may therefore not qualify for accreditation under existing standards as a conventional engineering degree. We view this not as a fatal objection but as a call for parallel action: alongside curricular innovation, the profession must engage accreditation bodies in a structured dialogue about revising standards to reflect the changing division of cognitive labor between engineers and AI systems. In the interim, institutions may consider positioning vibe-designer programs as a distinct professional credential—analogous to the emergence of computer science degrees alongside electrical engineering in an earlier era—rather than as a replacement for accredited engineering programs.

Table 1. Vibe-designer curriculum.

Lifecycle Phase	Tier	Year	Goal	Students' Competencies	Courses
Concept Formation & Foundation	Lower tier	1	Supporting requirement-level reasoning	Mathematical modeling Understanding computational complexity Relational thinking Statistical reasoning	Mathematics, logic, physics, chemistry, biology Information theory Topology Probability and statistics
Specification & Collaborative Generation	Replacement tier	2–3	Fostering effective collaboration with AI systems	Requirements articulation Latent space navigation Human-AI collaboration Flaw searching Verification and validation	Prompt engineering Latent space navigation Collaborative creation studios Adversarial audit labs Verification and validation frameworks

Table 1. *Cont.*

Lifecycle Phase	Tier	Year	Goal	Students' Competencies	Courses
Architecture & Integration	Replacement tier	2–3	Providing a solid multidisciplinary foundation	Taking into account broad engineering considerations Taking into account non-traditional engineering considerations	Introductory courses in various engineering fields Introductory courses in the social sciences and humanities
Integration, Operation & Ethical Oversight	Upper tier	4	Integrating transdisciplinary considerations into design decisions	Systems thinking Understanding regulatory frameworks Ethical responsibility Understanding social aspects of technology Evaluating environmental effects	Complexity science System engineering Engineering law Engineering ethics Sociology of technology Environmental engineering Sustainability

8. Illustrative Case Study: The Adaptive Neighborhood Energy Grid

To concretely illustrate the vibe-designer approach, we present a hypothetical case study—a thought experiment designed to demonstrate how vibe penetrates technical logic itself, how collaborative creativity might generate unexpected technical forms, and how the space between humans and AI could produce solutions that neither would achieve alone. While this scenario is constructed rather than empirical, it is grounded in realistic engineering constraints and current AI capabilities.

An urban neighborhood with heterogeneous development—residential buildings, small businesses, a school, and a community health clinic—faces problems of peak load stress and unreliable centralized electricity supply. The traditional solution would involve substation reinforcement and additional cable installation. A traditional power systems engineer would approach this project through a well-established sequence: calculate peak loads, design capacity increases, and optimize cable cross-sections—the classical problem of "demand → capacity → infrastructure." This represents individual creation: one solution type, parameter optimization within a predetermined framework.

8.1. The Vibe-Designer Approach

The vibe-designer begins not with power capacity but with the character of the neighborhood's energy behavior:

"A system that: (1) transforms consumers into participants—not passive demand but active resources; (2) exploits temporal heterogeneity—the school, clinic, and residences have different usage patterns, and this is an asset not a problem; (3) degrades gracefully—during failures, critical functions persist while non-critical ones reduce smoothly rather than cutting off abruptly; (4) learns and adapts—not static infrastructure but an evolving system."

Note how this specification already changes the type of solution under consideration. The vibe does not merely add requirements to a predetermined solution category; it opens the space to fundamentally different solution architectures.

8.2. Collaborative Iteration

In this scenario, the AI generates 30+ architectural concepts in response to this specification. Among them is an unexpected proposal: instead of reinforcing centralized supply, create an "energy metabolism" for the neighborhood where local storage (including residents' electric vehicles), the school's solar panels, and controllable loads form a distributed system that redistributes energy across time and space.

The vibe-designer recognizes the potential of this idea but identifies a problem: the AI's proposed topology assumes residents will rationally respond to price signals—a sociologically naive assumption. The specification is refined: "The system must function with indifference from 70% of participants, active engagement from 20%, and antagonism from 10%."

8.3. The Emergent Insight

Through this iterative process, an idea emerges that neither humans nor AI would likely have produced in isolation: the "energy contract" between buildings. The clinic has critical loads (vaccine refrigerators, medical equipment); the school has a large roof for solar panels but zero consumption during summer. The AI proposes formalizing inter-entity obligations: the school "guarantees" the clinic a certain power level in exchange for priority heating in winter.

The vibe-designer understands that this is not merely a technical solution but an institutional innovation—and here is precisely where the human role would be irreplaceable: the vibe-designer sees that implementation requires a legal contract template, an arbitration mechanism for failures, and a trust interface between institutions. The AI could not assess social feasibility; the human without AI would not have arrived at this configuration.

8.4. Demonstration of Core Competencies

The case study illustrates two of the core competencies of the vibe-designer described in Section 4.3.

- Adversarial Imagination—A central challenge in this scenario is grid instability under sudden load surges. The vibe-designer addresses this not by deriving protection relay settings, i.e., a middle-tier implementation task delegated to AI, but by: (1) specifying the failure mode explicitly in the initial vibe, e.g., "the system must degrade gracefully" and (2) adversarially probing the AI-generated topology, e.g., "what happens if 80% of electric vehicles charge simultaneously at 18:00 on a winter evening?" This sequence illustrates adversarial acuity in practice: the vibe-designer need not compute the fault current, but must know to ask the question and evaluate the answer.
- Systemic Contextualization—The proposed inter-entity energy contracts fall outside existing grid code frameworks in most jurisdictions. The vibe-designer must identify this constraint, specify it to the AI, e.g., "the architecture must comply with EU Directive 2019/944 on common rules for the internal electricity market," and evaluate whether the AI-generated contract templates satisfy the relevant provisions. This is not legal expertise in the classical sense; it is the capacity to locate the relevant regulatory boundary and incorporate it as a design constraint—a systemic contextualization task that defines the vibe-designer role.

8.5. Case Summary: Three Principles Illustrated

This hypothetical case study illustrates the three essential principles of the vibe-designer paradigm:

- Principle 1—Vibe Penetrates Technical Logic: The vibe-specification changes the very type of solution under consideration—from "increase capacity" to "create metabolism." This is a categorical shift, not parameter optimization.
- Principle 2—Collaborative Creativity Generates Unexpected Technical Forms: The inter-entity energy contracts represent a genuinely novel technical-institutional form that blurs the boundary between infrastructure and institution.
- Principle 3—The Space between Produces What Neither Could Achieve Alone: The human alone lacked the capacity to rapidly generate 30+ alternatives. The AI alone lacked contextual judgment to assess sociological realism and institutional feasibility.

9. Critical Challenges and Responses

The vibe-designer paradigm faces significant challenges that must be addressed for successful implementation.

9.1. The Verification Gap

The most significant challenge is what we term the "verification gap"—the distance between human intention and black-box implementation [41]. When AI generates a structural design, how can the vibe-designer be confident it is actually safe?

We propose several complementary approaches. The first approach is Adversarial Verification, namely, safety assurance comes not from understanding the implementation but from systematically attacking it [30]. The vibe-designer orchestrates confrontations between opposing AI models. The second approach is Formal Verification Where Applicable. In other words, for designs that can be formally specified, mathematical proof techniques can provide guarantees that do not require understanding implementation details. Statistical Validation can be helpful as well. For complex systems where formal verification is infeasible, statistical testing can provide confidence bounds. The last approach is Explainable

AI Integration. As AI systems become more capable of explaining their reasoning [44], the vibe-designer must develop skills in evaluating these explanations.

9.2. The Liability Question

Current legal frameworks assume that professional engineers understand their designs and bear responsibility for them [42]. When AI generates a design, who bears liability for failures? We propose a shift from "procedural accuracy" to "systemic oversight" as the basis for professional responsibility. The vibe-designer is liable not for the correctness of individual calculations but for:

- Specification Appropriateness: Did the specification adequately capture relevant requirements and constraints?
- Verification Process Rigor: Was the AI output subjected to adequate adversarial analysis, testing, and review?
- Evaluation Criteria Appropriateness: Did the multidimensional evaluation adequately represent stakeholder interests?
- Professional Judgment Exercise: Where AI outputs were ambiguous or conflicting, did the vibe designer apply appropriate expertise?

9.3. Cognitive Impact: Preserving Engineering Intuition

Perhaps the deepest concern is whether bypassing hands-on design diminishes what experienced engineers call "gut feel" [10, 11]. We acknowledge this concern as legitimate and propose several responses: We stress that "compressing" the middle tier does not mean eliminating low-level engagement. What is compressed is time-to-competency in routine implementation; what is retained and concentrated are those hands-on experiences that specifically develop anomaly recognition and failure intuition—the capacity to notice that something "feels wrong" in an AI-generated design. Research on expertise development consistently indicates that this capacity requires direct exposure to failure rather than prolonged practice of routine success. The mechanisms described below are designed accordingly.

The first response is Compressed Experiential Learning, namely, intensive "design immersions" where students engage with implementation under time pressure. Failure Case Libraries in which students engage intensively with historical failures—studying not just what went wrong but the warning signs that were missed—are also useful. Another response is Simulation-Based Training. Advanced simulations allow students to experience the consequences of design decisions at an accelerated tempo. Finally, Hybrid Career Paths are suggested. Some practitioners will continue to develop deep implementation expertise, serving as specialized "technical auditors."

9.4. Student Identity and Psychological Readiness

A challenge that cuts across all of the above is the psychological readiness of engineering students to relinquish the design phase—traditionally the core of engineering activity—to an AI agent. According to self-determination theory [45], the design process satisfies fundamental psychological needs for autonomy (including creativity), competence, and relatedness to a professional community [46]. Delegating this process to AI may provoke resistance among students who perceive such delegation as a threat to their emerging professional identity. The vibe-designer curriculum must therefore attend not only to cognitive skill development but also to the cultivation of alternative sources of autonomy, competence, and professional belonging—sufficient to sustain intrinsic motivation. Whether the curricular mechanisms proposed above (collaborative creation studios, adversarial audit labs, and transdisciplinary integration) can fulfil this function remains an open empirical question that pilot programs should investigate.

10. Discussion

The vibe-designer paradigm, as presented in the preceding sections, raises several interconnected issues that warrant broader discussion.

First, the relationship between the vibe-designer and existing engineering roles requires clarification. We do not envision a wholesale replacement of traditional engineers by vibe-designers. Rather, we anticipate a diversification of engineering roles analogous to what occurred after the First Great Specialization. Just as theorists and experimentalists developed complementary expertise, vibe-designers and implementation specialists may form symbiotic professional relationships [2, 31]. The relative proportion of each role will likely vary by domain—software engineering may shift more rapidly toward vibe-design than civil or aerospace engineering, where physical verification remains essential.

Second, the collaborative creativity paradigm raises questions about assessment and quality standards. If creative outcomes emerge from human-AI dialogue rather than individual effort, how should we evaluate engineering work? Traditional metrics—code quality, calculation accuracy, and design elegance—apply to outputs but not to the collaborative process itself. New quality frameworks may need to evaluate the sophistication of specification, the rigor of adversarial testing, and the breadth of contextual consideration [32, 41].

Third, our framework intersects with broader debates about the future of work in the age of AI [22, 23]. The vibe-designer paradigm suggests that the most productive response to AI automation is neither resistance nor passive acceptance but active reconceptualization of professional roles around distinctively human capacities. This aligns with perspectives that emphasize human-AI complementarity rather than substitution [40].

Fourth, the vibe-designer curriculum warrants comparison with established systems engineering education models, both to clarify its distinctive contribution and to identify points of productive continuity. Three reference frameworks are particularly relevant: the CDIO initiative, MBSE education programs, and digital-twin-integrated curricula.

The CDIO initiative, mentioned in Section 2, represents the most widely adopted reform of classical engineering education [1, 2]. Like the vibe-designer curriculum, CDIO emphasizes contextualized learning, professional competencies, and integration across disciplinary boundaries. However, CDIO retains the full tripartite structure and treats implementation as a core graduate attribute. The vibe-designer curriculum diverges precisely at this point: it does not reform the implementation tier but strategically compresses it, redirecting the liberated curriculum space toward AI-mediated specification and adversarial evaluation. Where CDIO asks "how can we make implementation learning more contextualized?", the vibe-designer curriculum asks "what replaces implementation learning when AI assumes that function?" These are complementary rather than competing questions, and programs inspired by CDIO could serve as a natural baseline against which vibe-designer pilot outcomes are evaluated.

MBSE education programs, also mentioned in Section 2, emphasize formal modelling languages (e.g., SysML, MATLAB/Simulink), model validation, and the management of system complexity through structured representation [16]. The vibe-designer curriculum shares MBSE's commitment to system-level thinking and requirements traceability, but differs sharply in its epistemological stance toward formalism. Where MBSE assigns central weight to formal modelling competency, the vibe-designer curriculum treats formal verification as one tool among several in the adversarial evaluation toolkit—important but not foundational. This reflects a broader claim: that the requirement LoA, not the model level, is the primary locus of human contribution in AI-enabled engineering. The practical implication is testable: vibe-designer graduates should outperform MBSE-trained engineers on tasks requiring rapid multi-domain contextualization, while MBSE-trained engineers should outperform them on tasks requiring rigorous formal consistency checking.

Digital-twin-integrated curricula [47] represent perhaps the closest existing analog to the vibe-designer approach. By requiring students to develop, interrogate, and maintain a living digital replica of a physical system, these programs cultivate precisely the adversarial and evaluative stance that the vibe-designer paradigm foregrounds. The key difference lies in scope: digital twin pedagogy typically operates within a single engineering domain and retains implementation competency as the basis for model construction. The vibe-designer curriculum generalizes the evaluative stance across domains and explicitly decouples it from implementation—the vibe-designer interrogates AI-generated models without necessarily having constructed them. Digital-twin programs could therefore serve as a productive partial instantiation of the vibe-designer curriculum, particularly for CCPSH systems where cyber-physical co-simulation is a central design activity.

A fifth dimension of discussion concerns the application of the vibe-designer paradigm specifically to CCPSH systems—the class of systems foregrounded in this Special Issue. As explained in Section 1, CCPSH systems are characterized by multi-constituent heterogeneity, by embeddedness in social and institutional contexts, and by the presence of AAI-, GAI-, PAI-, or EAI-enabled components that generate emergent behavior not reducible to individual subsystem specifications. These characteristics make them precisely the domain in which vibe-designer competencies are most critical and most difficult to develop. The specification-articulation competency, applied to CCPSH contexts, must capture not only functional requirements but the relational properties of heterogeneous constituents, i.e., the latency constraints between the cyber and physical layers, the trust and accountability norms governing human-AI teaming, and the institutional conditions under which an agentic design system-of-systems may be safely delegated autonomous decision authority. The adversarial-imagination competency must extend to multi-domain failure cascades—scenarios in which a software fault propagates into physical actuation with social consequences. These are qualitatively different from single-domain verification challenges and require correspondingly richer training environments. We propose that the vibe-designer curriculum incorporate at minimum one capstone module on CCPSH system integration that uses real-world case studies of agentic design failures and near-misses as the primary pedagogical material.

In addition, the ethical dimension of vibe-design deserves emphasis. The vibe-designer's position as moral proxy[7, 38] carries substantial responsibility. As AI systems become more capable, the temptation to delegate not only implementation but also evaluation may grow. Maintaining the human role in value-laden decisions—rather than allowing it to erode through automation creep—is perhaps the most important long-term challenge for the paradigm.

Finally, it is useful to project the implications of the vibe-designer paradigm across a ten-year horizon through three conditional scenarios. These are structured projections, not predictions—their validity is contingent on the trajectory of AI capability development.

- Scenario A (software-dominant domains): AI implementation capabilities reach professional-grade reliability in software engineering by 2028–2030. Demand for vibe-designers in software-intensive sectors grows rapidly; accreditation bodies begin piloting frameworks that assign credit for adversarial audit skills and specification quality.
- Scenario B (heterogeneous cyber-physical systems (CPS) domains): In aerospace, automotive, and medical devices, the transition is slower and hybrid. Vibe-designers work alongside implementation specialists, responsible for system-of-systems architecture, regulatory compliance, and CCPSH integration—the scenario most directly relevant to this Special Issue.
- Scenario C (transdisciplinary accreditation): Independent of AI capability pace, the transdisciplinary competency model gains traction in ABET and ENAEE discourse, driven by industry demand for engineers who navigate sociotechnical complexity. These scenarios are offered as analytical instruments for evaluating the robustness of curricular investments under different futures.

11. Implications for the Broader Profession

The vibe-designer paradigm has implications that extend beyond curriculum development to the structure of the engineering profession as a whole.

Engineering professional identity has long centered on technical virtuosity[1]. The vibe-designer paradigm shifts this identity toward orchestration, judgment, and integration. The collaborative creativity framework provides resources for managing this identity transition: rather than viewing the change as a loss of creative agency, the profession can reframe it as a transition to a different mode of creativity.

We anticipate generational dynamics similar to those that accompanied previous technological transitions. Managing this transition will require sensitivity to the legitimate concerns of both older practitioners who built careers on implementation expertise and younger practitioners who develop within the new paradigm.

The vibe-designer's transdisciplinary competencies create new interfaces with adjacent professions. The emphasis on ethics, law, and social impact creates common ground with policy professionals. The focus on stakeholder needs resembles aspects of design thinking and user experience practice[31]. Rather than viewing these overlaps as threats to professional territory, we see them as opportunities for productive collaboration.

The vibe-designer paradigm may have significant implications for access to engineering careers. Traditional engineering education requires extensive laboratory facilities, expensive equipment, and specialized infrastructure. If the middle phase is compressed, the capital requirements for engineering education may substantially decrease, potentially democratizing access. However, there are countervailing risks: if vibe-designer education emphasizes transdisciplinary integration, it may favor students with broader educational backgrounds, potentially disadvantaging those with narrow technical preparation.

12. Limitations

This paper does not present empirical validation. Several limitations follow from this scope.

The vibe-designer paradigm is a hypothesis about educational and professional futures, not a report of tested outcomes. We have not conducted longitudinal studies comparing graduates of traditional and vibe-designer curricula. The historical analogies and case illustrations we provide are meant to establish plausibility, not to demonstrate efficacy. Pilot programs with systematic assessment would be necessary to move from a theoretical proposal to an evidence-based recommendation.

Our framework assumes continued advancement in generative AI implementation capabilities. The specific curricular balance we propose depends on AI systems becoming reliable enough to serve as implementation partners in professional engineering contexts. If this trajectory slows or plateaus, a more gradual transformation would be appropriate. Our proposal should be understood as conditional: if AI implementation capabilities reach professional-grade reliability, then the vibe-designer paradigm becomes viable and perhaps necessary.

We have presented the vibe-designer as a general paradigm, but implementation requirements likely vary across engineering domains. Software engineering may be more amenable to AI-mediated implementation than civil or aerospace engineering, where physical constraints are unforgiving. A fuller treatment would differentiate curricular recommendations by domain.

A further open empirical question deserves explicit framing for future research: Would a vibe-designer who completed the full three-tier curriculum outperform one who omitted the middle tier? Our hypothesis is that the answer depends on domain and task: in detail-intensive single-domain applications, full-tier graduates will likely perform better; in CCPSH system integration and stakeholder-context tasks, the compressed-tier graduate may be comparably or better equipped—having invested the middle-tier time in transdisciplinary integration rather than routine implementation drill. Longitudinal pilot studies comparing these two trajectories constitute a high-priority empirical research question for the field.

Our treatment of embodied expertise—the intuitive judgment that develops through hands-on implementation experience [10, 11]—remains incomplete. We have proposed mechanisms that might preserve essential intuitions while reducing implementation coursework, but we have not established that these mechanisms are sufficient. This is perhaps the deepest open question our framework raises: What is the minimum embodied engagement necessary for effective engineering judgment?

13. Research Agenda

The vibe-designer paradigm raises profound research questions spanning cognitive science, legal studies, human-computer interaction, and engineering education. The key questions are given in **Table 2**.

Table 2. Research domain summary.

Research Domain	Key Questions
Cognitive Science	Effects of bypassing hands-on design on failure mode recognition; development of collaborative creativity skills; minimum thresholds of embodied practice for expertise
Legal/Policy	Liability allocation between human specifier and AI implementer; documentation standards for verification; professional licensing adaptation
Human-Computer Interaction	Formal Vibe Languages (FVL); interface design for latent space navigation; AI explanation structures; creativity-supporting interfaces
Engineering Education	Curricular sequences for collaborative creativity; assessment of relational creativity; collaborative creation studio pedagogies

Table 2. *Cont.*

Research Domain	Key Questions
Creativity Research	Nature of emergent creativity in human-AI dialogue; comparison of individual vs. collaborative creation outcomes
Ethics and Philosophy	Distributed agency and moral responsibility; anticipatory ethics methods; value-sensitive design in AI-mediated contexts

14. Conclusions

The vibe-designer represents one among many emerging professional paradigms being reshaped by generative AI—not automated and eliminated, but elevated to a new level of abstraction where human judgment, contextual understanding, and ethical reasoning become the essential contributions. Central to this reshaping is the transformation from individual creation to collaborative creation. The engineer of the future will not be a solitary figure at the keyboard, producing designs through individual cognitive effort. Rather, the engineer will be a collaborator in dialogue with AI systems, with creative outcomes emerging in the space between human intentionality and machine capability. This transformation is neither utopian nor dystopian but genuinely novel. It preserves a meaningful role for human expertise while radically changing what that expertise entails. It requires new educational approaches, new professional structures, and new frameworks for responsibility and accountability.

The historical parallel with the First Great Specialization is instructive. The division of theory and experiment in the seventeenth century initially seemed to many like a diminution of the natural philosopher's role. In retrospect, it enabled both theoretical and experimental work to develop to heights that the integrated universal scholar could never have achieved. We believe an analogous dynamic may characterize the Second Great Specialization. The collaborative creativity paradigm reframes this transition not as loss but as evolution. The vibe-designer who masters provocative articulation, discerning selection, and developmental iteration may prove more creative, not less, than the traditional engineer working alone.

As a constructive position paper, this work advances three innovative propositions that warrant systematic investigation. First, the strategic compression of the implementation tier is not a deficit but an epistemological reorientation grounded in Floridi's level-of-abstraction analysis: the vibe-designer operates at the requirement LoA, where different observables, operators, and predicates govern professional reasoning. Second, engineering creativity in the AI era is relational rather than individual: it emerges in the dialogical space between human intentionality and machine capability, and must therefore be cultivated through new pedagogical forms, such as collaborative creation studios and adversarial audit labs. Third, the appropriate site for this paradigm is the class of CCPSH systems, where multi-constituent heterogeneity and emergent behavior make the requirement LoA the only level at which integrative oversight is possible. These propositions are tested in the sense that they are derivable from established philosophical frameworks and consistent with current empirical work on human-AI oversight; they are innovative in that, taken together, they reorganize engineering education around a new professional figure.

Future research and development should focus on three priorities: (i) longitudinal pilot studies comparing vibe-designer and traditional engineering graduates on CCPSH integration tasks; (ii) empirical investigation of the curricular mechanisms proposed for preserving embodied intuition; and (iii) engagement with accreditation bodies (e.g., ABET and ENAEE) toward standards that reflect the changing division of cognitive labor between engineers and AI systems.

We invite the global engineering education community to engage seriously with this reshaping. The transition will not be smooth; there will be failures, resistance, and unintended consequences. But the alternative—clinging to curricular structures designed for an era of manual implementation—risks making engineering education increasingly disconnected from actual practice. The vibe-designer represents not the end of engineering but its next chapter: one in which human and artificial intelligence collaborate to address problems of unprecedented complexity, and in which the human contribution centers precisely on those capacities—judgment, values, contextual understanding, and collaborative creativity—that remain distinctively ours.

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AI Use Statement

During the preparation of this manuscript, the authors used Claude (Anthropic) solely for language refinement. No AI tools were used for data analysis, interpretation, or generation of scientific content. All outputs were critically reviewed and edited by the authors. The authors take full responsibility for the integrity and accuracy of the work.

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