

The IDEA Design Scaffold: Empowering Novice Designers with Systemic and Sustainable Design Education

Ioannis Xenakis

Complex Systems and Service Design Lab, Department of Product and Systems Design Engineering, University of the Aegean, Syros, Greece
ixen@aegean.gr

Despina Grigoreli

Complex Systems and Service Design Lab, Department of Product and Systems Design Engineering, University of the Aegean, Syros, Greece
d.grigoreli@aegean.gr

Abstract: Designing for complex sociotechnical systems challenges novice designers, requiring them to align abstract systemic priorities with actionable functional goals. The IDEA Design Scaffold (IDEAS) addresses this by integrating hierarchical goal-setting, systemic affordances (SysAf), and iterative feedback loops into a structured framework. At its core, the Iterative Innovation Cycle (IIC) guides designers through iterative exploration and refinement, enabling the evolution of foundational affordances into innovative solutions that balance operational clarity with systemic priorities. IDEAS organizes design goals across Systemic Levels (SL), helping students deconstruct high-level objectives into actionable subgoals while maintaining systemic alignment. SysAf emerges dynamically, linking functional feasibility with broader societal and ecological goals. Designed to support the transition from isolated problem-solving to dynamic systems thinking, this structured approach aims to prepare novice designers to engage with complex challenges such as urban mobility, healthcare ecosystems, and sustainability-driven policies. Its conceptual flexibility makes it suitable for both tangible product design and intangible service systems.

This paper presents the theoretical and methodological foundations of IDEAS, positioning it as a tool for structuring creative ideation in systemic design. While examples from educational settings are included to illustrate the framework's potential application, the focus remains on articulating its conceptual architecture and developmental rationale. IDEAS offers methodological support for navigating abstraction, balancing multi-level design goals, and addressing the challenges of sustainability, equity, and complexity in contemporary design contexts.

Keywords: *Systemic Design Education; Sociotechnical Complex Systems; Systemic Affordances; Design Thinking; Systemic Innovation in Design*

Introduction: Rethinking Design Education for Complex Challenges

The increasing complexity of global challenges such as climate change, urban mobility, and public health necessitates a transformation in design education. These challenges are inherently systemic, spanning disciplines, cultures, and societal priorities. Traditional methodologies, which emphasize linear processes and artifact-focused practices, often fail to address the interconnected nature of such issues. Designers must navigate sociotechnical systems characterized by interdependencies, emergent behaviors, and evolving constraints. Such systems are multilayered (Meadows, 2008) interdependent, and continuously evolving—where functional, societal, and ecological factors interact across systemic levels (Bauer & Herder, 2009; Jonker & Harmsen, 2012; Wang et al., 2018). To meet these demands, design education



This work is licensed under a Creative Commons Attribution-NonCommercial-Share Alike 4.0 International License. <https://creativecommons.org/licenses/by-nc-sa/4.0/>

must embed interdisciplinary collaboration, systemic thinking, and long-term sustainability at its core (Banathy, 1996; Norman & Stappers, 2015).

The IDEA Design Scaffold¹ (IDEAS) addresses this gap by introducing a methodological framework that supports creative ideation as a structured, developmental process. Rather than offering a fixed sequence of tools or stages, IDEAS integrates systemic design goals—such as sustainability, equity, and resilience—with cognitive-developmental mechanisms that guide how ideas evolve through interaction with systemic complexity. Grounded in principles of complex systems and systemic design (Design Council, 2022; Dubberly & Pangaro, 2023; Jones, 2014; Norman & Stappers, 2015; Sevaldson, 2022; Tuunanen, Tuure et al., 2024), the Scaffold builds on established models on recursive constructivist models (Campbell & Bickhard, 1986; Christensen & Hooker, 2000; Hooker, 1994) and theories of developmental creativity (Bickhard, 1992, 2005a; Feldman, 1989, 1999; Xenakis & Arnellos, 2025).

In contrast to creativity models that assume a stable representational space (Sternberg, 2003), IDEAS conceives ideation as a recursive, exploratory process involving the continual reorganization of idea constructs in response to feedback, constraints, and evolving goals (Bickhard, 2007). Within this recursive constructivist framework, creative exploration is not the selection of predefined alternatives but the developmental transformation of what counts as an option within a domain—transformations that are functional for the system's goal (Feldman, 1989; Hui et al., 2019; Simonton, 2000; Weisberg, 1999). Self-scaffolding learning practices enables creative thinkers to construct novel trajectories through recursive interaction with uncertainty, reorganizing understanding across levels of abstraction (Xenakis & Arnellos, 2025).

IDEAS is not a linear methodological framework but a feedback-sensitive structure—anchored in the methodological phases of Systemic Breakdown and Systemic Integration—that enables ideation to unfold as a process of systemic learning and creative transformation. Complementing this, IDEAS incorporates Carver and Scheier's (2012, 2017) hierarchical feedback model of goal regulation, operationalizing how designers navigate and align functional, interactional, systemic, and long-term goals across multiple systemic levels. Systemic Breakdown enables designers to deconstruct complex goals into actionable subgoals, revealing interdependencies across systemic levels (Dubberly & Pangaro, 2023; Norman & Stappers, 2015; van der Bijl-Brouwer & Malcolm, 2020). Systemic Integration synthesizes these subgoals into cohesive interventions, aligning functional goals with societal and ecological priorities (Midgley, 2000). Together, these phases empower designers to bridge disciplinary boundaries, integrate diverse perspectives, and create adaptive, sustainable solutions.

A key conceptual contribution of IDEAS is systemic affordances (SysAf)—opportunities within systems that dynamically emerge during the design process, revealing innovative ways for intervention. SysAf align functional and systemic goals, enabling designers to navigate complexity while fostering innovation and sustainability (Xenakis & Arnellos, 2013, 2014). Unlike static or isolated affordances, SysAf highlight dynamic interconnections within systems, guiding designers in developing interventions that address societal and ecological imperatives. For instance, in designing a school transportation system, the interplay between modular vehicle designs and urban equity can reveal a SysAf that promotes sustainability while fostering inclusivity.

The Iterative Innovation Cycle (IIC) serves as the methodological backbone of IDEAS, supporting the dynamic evolution of ideas through innovation and development trajectories. The innovation trajectory fosters the construction of SysAf at higher systemic levels, while the development trajectory ensures these affordances are grounded in feasibility at lower levels. By aligning design concepts with systemic goals, the IIC helps students navigate complexity and ambiguity as their interventions evolve dynamically across systemic levels goals (Azevedo & Hadwin, 2005).

This paper does not present a formal evaluation or empirical study of the IDEA Design Scaffold. Its primary aim is to introduce the theoretical and methodological foundations of the Scaffold, grounded in developmental and systemic design theory. The brief reference to its use in studio contexts is included solely to illustrate how its core concepts—Systemic Breakdown, Systemic Integration, and feedback-sensitive ideation—can be embedded within a design education setting. These examples are not offered as evidence of effectiveness, but as contextual illustrations to help clarify the framework's potential application.

¹ The acronym—IDEAS (*Interdisciplinary Design for Education, Action and Systems*)—informs the name IDEA Design Scaffold, which will be used interchangeably with “IDEAS” or “the Scaffold” throughout the text.

Implemented in the Department of Product & Systems Design Engineering at University of the Aegean, IDEAS introduces systemic ideation into two key studios: Ideation and Concept Design. In Ideation, students engage with Systemic Breakdown to generate diverse initial ideas, which are refined into cohesive interventions in Concept Design through collaborative synthesis. These iterative experiences empower novice designers to address societal and ecological imperatives, fostering a systems-oriented mindset.

The following sections explore the theoretical foundations of IDEAS (Section 2), its operational phases (Section 3), and its pedagogical contributions to sustainable design education (Section 4).

Foundational Principles of the IDEA Design Scaffold for Systemic Design Education

The IDEA Design Scaffold is grounded in systemic thinking principles that underpin its framework for navigating complex sociotechnical systems. These principles empower designers to engage with interdependencies, emergent behaviors, and long-term sustainability while maintaining coherence across Systemic Levels of abstraction (SL). By embedding hierarchical goal-setting, feedback loops, and the constructive evolution of ideas, the scaffold bridges abstract systemic priorities with functional design interventions.

Hierarchical Goal-Setting Across Systemic Levels

We understand creative exploration in systemic task environments as an iterative, learning-driven developmental process—one in which designers construct and remodulate their understanding over time through recursive interaction with uncertainty, feedback, and systemic complexity (Bickhard, 1992, 2005a; Feldman, 1989, 1999; Xenakis & Arnellos, 2025). This developmental dynamic calls for hierarchical goal attainment that supports the reorganization of idea constructs not only within a fixed representational frame, but across layers of challenge and abstraction. Within this dynamic, self-directed scaffolding becomes essential: creative exploration requires the stabilization of idea constructs before novel ones can emerge. Designers construct new framings by decomposing challenges into subproblems, exploring idealized cases, and—crucially—drawing on locally available resources that may not be accessible across contexts. This adaptive capacity reflects a developmental strategy: to stabilize novelty under shifting constraints structured by the designer through evolving goal hierarchies.

At the foundation of the IDEA Design Scaffold lies the principle of hierarchical goal-setting, which organizes systemic challenges into interconnected levels of abstraction. Rooted in

(2017) hierarchical feedback model of goal regulation, this approach enables designers to deconstruct complex challenges into manageable subgoals while ensuring alignment with overarching objectives. These subgoals serve as reference values—internal conditions that regulate feedback and define what counts as success at each systemic level. Reference values structure how ideation is evaluated, guiding self-directed processes of maintaining, reorganizing, or discarding emergent configurations. Each systemic level contributes to a coherent and adaptive design process, ensuring that functional interventions at lower levels serve broader societal and ecological priorities at higher levels (Figure 1, Part B).

The Scaffold proposes for novice designers four systemic levels (SL) of abstraction, summarized in Table 1, which provide a structured framework for aligning functional and systemic priorities. This hierarchy enables designers to trace the evolution of ideas logically across abstraction levels while remaining responsive to emerging systemic insights.

Table 1 Systemic Levels of Abstraction (SL) in the IDEA Design Scaffold

	FOCUS	ROLE IN GOAL STRUCTURING	EXAMPLE (SCHOOL TRANSPORT)
SL+2: METASYSTEM	Long-Term, Sustainability and Resilience Goals	Provides overarching systemic direction for innovation and reorganization across all lower levels.	Establishing decentralized energy-sharing networks for schools
SL+1: SYSTEM	Med- to Long-Term, Sociocultural and ecological Goals	Regulates the legitimacy, equity, and stakeholder alignment of lower-level actions	Ensuring equitable access to urban mobility

SL: INTERACTION	Med-Term, Integration and Reliability Goals	Coordinates how operational tasks are sequenced and adapted to ensure usability and system coherence	Real-time monitoring systems for bus safety
SL-1: OPERATIONAL	Short-Term, Situated Functionality Goals	Defines immediate design actions and technical feasibility within local constraints	Designing energy-efficient buses

This structured approach to goal-setting mirrors the nested organization of sociocultural and sociotechnical systems themselves. As Meadows (2008) emphasizes, such systems are composed of subsystems whose goals are embedded within broader systemic priorities. Each level—from operational actions to institutional visions—must function semi-independently while remaining responsive to higher-level aims. If these goals are not coherently aligned, the system may produce conflicting or counterproductive outcomes, even when operating as designed. By structuring ideation according to these natural hierarchies, the Scaffold enables designers to engage with systemic complexity in a way that reflects how real-world systems actually function and evolve.

By organizing design challenges into systemic levels, the Scaffold provides a roadmap for navigating complexity. For example, SL+2 goals like reducing fossil fuel reliance guide SL+1 systemic opportunities, such as equitable urban mobility. These, in turn, shape SL-level designs, such as dynamic scheduling systems, which are grounded in SL-1 functional clarity, such as energy-efficient buses. This progression exemplifies not only a top-down trajectory, in which abstract priorities are translated into actionable subgoals, but also a bottom-up trajectory, wherein those subgoals are reassembled into cohesive design interventions that remain aligned with higher-level systemic aims. These two complementary processes—referred to in the Scaffold as Systemic Breakdown and Systemic Integration—enable designers to move iteratively between goal decomposition and synthesis, maintaining coherence across levels of abstraction.

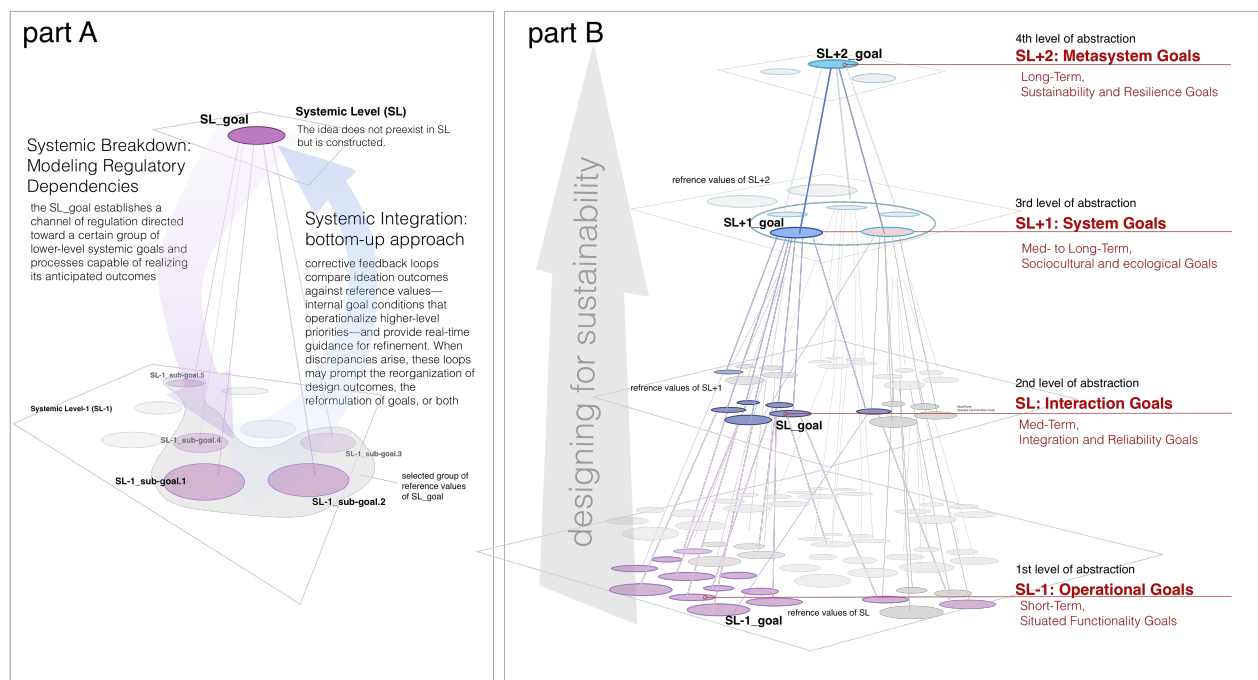


Figure 1 **Part A:** Visualizes the systemic hierarchy, illustrating relationships between abstraction levels, feedback loops, and iterative refinement. **Part B:** Details the hierarchical structure of Systemic Levels (SL) within the IDEA Design Scaffold, connecting functional, societal, and ecological priorities.

Feedback Loops as Mechanisms for Iterative Engagement

Feedback loops are integral to the Scaffold's iterative approach, enabling dynamic engagement across systemic levels and fostering adaptive learning. Rooted in self-scaffolding theory and recursive constructivism (Bickhard, 2005), feed-

forward and error-feedback mechanisms integrate top-down guidance with bottom-up insights, ensuring that design actions remain aligned with systemic goals.

The importance of feedback in complex design systems is not limited to learning; it reflects a deeper systemic logic. As Meadows (2008) emphasizes, feedback loops are the essential mechanism through which complex systems self-regulate, adapt to changing conditions, and maintain coherence across scales. They allow systems to monitor performance, correct course dynamically, and remain responsive to both internal inconsistencies and external disruptions. Without feedback, systems become either rigid and fragile or drift uncontrollably. Within design, this means that feedback loops are not merely useful—they are structurally necessary for any methodology aiming to intervene meaningfully in dynamic sociotechnical environments.

Following Meadows (2008) and Bickhard (2005) we distinguish two complementary regulatory functions of feedback that enable designers to navigate complexity:

- **Proactive (anticipative) feedback** supports exploratory processes by generating expectations about future opportunities. These loops help designers identify indications of emerging needs or constraints, facilitating the construction of what we call systemic affordances—context-sensitive opportunities for creative intervention (Xenakis & Arnellos, 2013). These mechanisms are what enable novelty to emerge in ideation.
- **Corrective (reactive) feedback** stabilizes the design trajectory by evaluating whether emerging ideas remain functionally and systemically aligned. This form of feedback addresses discrepancies between goal expectations and developing representations across systemic levels, thereby sustaining continuity and enabling the emergence of robust, innovative scaffolds (Bickhard, 2007). These mechanisms are what enable ideation to remain effective and durable.

For instance, while implementing SL-1 goals like energy-efficient bus operations, feedback loops evaluate whether these actions align with SL priorities, such as user experience. Proactive feedback may suggest adapting configurations to underserved regions (SL+1), while corrective feedback refines operational tasks to maintain alignment with broader sustainability goals (SL+2). In this way, feedback loops operate continuously to structure learning, refine design representations, and guide the systemic evolution of ideas.

Constructive Evolution of Ideas and Systemic Affordances

A defining contribution of the Scaffold is its emphasis on the constructive evolution of ideas as systemic opportunities for intervention within a task environment. In the context of design thinking, Xenakis and Arnellos (2013) describe interaction affordances as such dynamic opportunities. Building on this, we introduce the term systemic affordances (SysAf) to capture both the developmental and systemic dimensions. Systemic affordances emerge when internal anticipatory structures and external conditions jointly indicate that a potential intervention could be both novel and appropriate if selected—fulfilling hierarchical goal structures. They do not refer to fixed features of the environment but to dynamic relations between the designer and the sociocultural context in which they operate. Interaction affordances represent immediate opportunities tied to SL-1 functional goals, providing tangible starting points for design exploration. Over time, these evolve into SysAf, which align functional actions with systemic priorities at higher abstraction levels.

Sustainability Path Example: As depicted in Figure 3, along the sustainability path, an SL-1 affordance such as “energy-efficient operation” evolves into an SL+1 systemic affordance like “integrating modular buses with renewable energy-sharing networks.” Proactive feedback during this process highlights opportunities for reducing urban congestion, while corrective feedback ensures technical feasibility. Ultimately, these systemic affordances become aligned with SL+2 goals, such as the creation of decentralized energy grids that reduce fossil fuel reliance.

Embedding Coherence Across Interconnected Systems

Maintaining coherence across systemic levels is critical in systemic design, where interdependencies and emergent behaviors add complexity (Meadows, 2008; Sevaldson, 2022). The Scaffold ensures coherence and systemic affordances into its hierarchical structure, allowing iterative regulation of goal alignment across functional, interactional, and systemic priorities (Bickhard, 2007; Xenakis & Arnellos, 2013).

For instance, a modular bus system initially focused on SL-1 energy efficiency evolves through iterative engagement to enhance equity at SL+1. This evolution might include adaptive configurations that serve diverse community needs—reflecting what Meadows (2008) describes as multi-level system adaptation. Feedback mechanisms guide this

progression to ensure alignment with SL+2 sustainability goals, such as decentralized energy networks that reduce reliance on fossil fuels.

By embedding coherence across systemic levels, the Scaffold fosters adaptability while maintaining systemic alignment, ensuring each intervention contributes meaningfully to broader objectives.

Systemic Thinking in Design Education

The principles outlined above form the foundation of the IDEA Design Scaffold, equipping novice designers to navigate the complexities of systemic design through a ‘learning by doing’ pedagogy (Yelland et al., 2008). This structured scaffolding approach aligns with established models of constructivist learning, in which students progressively internalize complex cognitive structures through guided engagement (Bickhard, 2007). The Scaffold’s integration of hierarchical goal-setting, feedback loops, and iterative synthesis supports self-scaffolding ways to learning (Bickhard, 2007) enabling students to reorganize their understanding in response to systemic complexity. This in turn fosters the ability to elevate ideation toward higher levels of learning, where systemic priorities become increasingly abstract and developmentally structured (Carver & Scheier, 2017; Xenakis, 2025; Xenakis & Arnellos, 2025).

By integrating hierarchical goal-setting, feedback loops, and SysAf, the Scaffold fosters a mindset that prioritizes interconnectedness, adaptability, and sustainability. For example, in systemic education, students apply the paths of deconstruction to abstract challenges like urban mobility, breaking down SL+2 goals into SL+1 opportunities and SL tasks. These experiences encourage designers to transcend isolated problem-solving, fostering a systemic perspective that aligns their work with societal and ecological imperatives.

In summary, IDEAS operationalizes systemic thinking through a structured framework that bridges foundational insights with systemic innovation. This approach prepares a new generation of designers capable of addressing interconnected sociotechnical challenges while fostering sustainable and impactful solutions. Building on these principles, the following section details how the IDEA Design Scaffold operationalizes systemic thinking through its two key phases: Systemic Breakdown and Systemic Integration.

The IDEA Design Scaffold: From Systemic Breakdown to Creative Integration

Understanding and designing complex systems requires both top-down analysis—which identifies regulatory structures—and bottom-up synthesis, which explores how novel configurations can emerge through interaction (Bunge, 2014). The IDEA Design Scaffold is grounded in this systemist philosophy. It operationalizes systemic thinking through two interwoven phases: Systemic Breakdown and Systemic Integration.

These phases do not represent linear steps but recursive modes of exploration that allow designers to deconstruct systemic goals and reconstruct them through creative development. Systemic Breakdown, as a top-down approach, enables designers to model how goals are organized across hierarchical levels of abstraction, identifying the interdependencies and reference values that shape a complex system’s regulatory structure. In contrast, Systemic Integration, as a bottom-up scaffolding process (Bickhard, 2007), intrinsically motivates the creative construction (Amabile & Pratt, 2016; Csikszentmihályi, 1988) and refinement of systemic affordances for intervention (SysAf) transforming modeled goal structures into viable design possibilities through iterative exploration, feedback, and reorganization (see Figure 2).

Unlike traditional methods like TRIZ or Syntectics, which focus on re-designing existing solutions, Systemic Breakdown and Integration provide a developmental architecture for ideation—one that enables novelty to emerge while preserving idea stabilization and coherence with broader societal and ecological priorities, equipping designers to navigate the complexity of sociotechnical systems. The following sections detail the two phases of the Scaffold—Systemic Breakdown and Systemic Integration—highlighting their role in deconstructing abstract challenges and constructing impactful solutions.

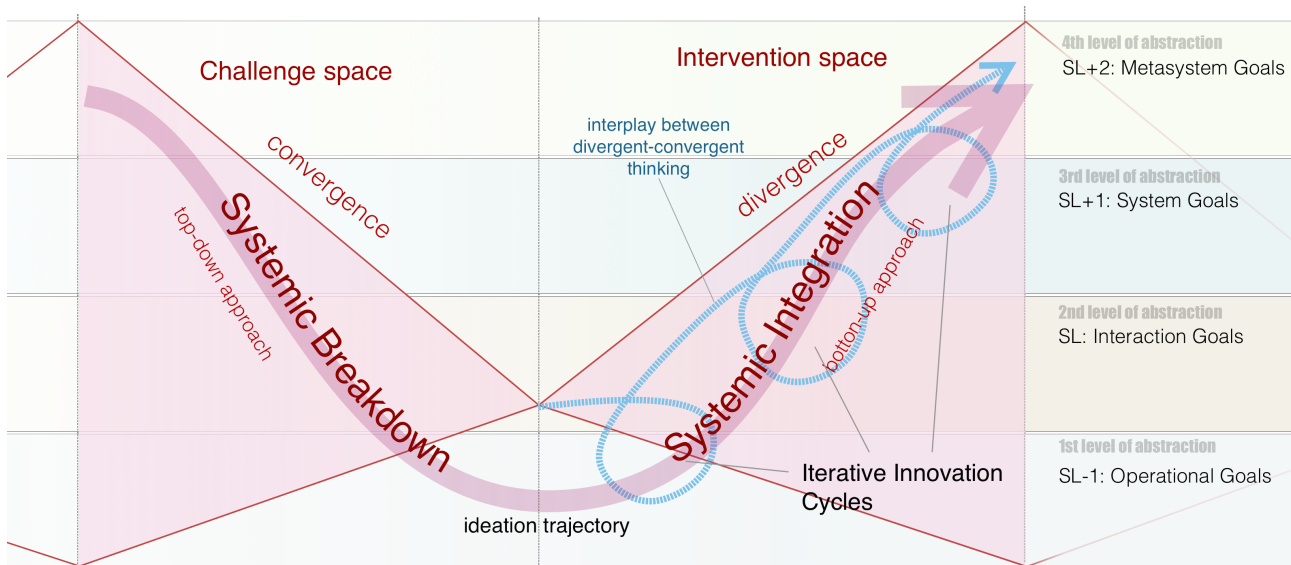


Figure 2 The IDEA Design Scaffold Framework: illustrating Systemic Breakdown (top-down) and Systemic Integration (iterative upward trajectory) across the challenge and intervention spaces.

Systemic Breakdown: Deconstructing Complexity

Based on Carver and Scheier's (2017) hierarchical model of goals and Campbell and Bickhard's (1986) systemic levels of abstraction, we situate both Systemic Breakdown and Systemic Integration within a multi-level design framework that guides goal-setting and ideation across hierarchical layers of a system (see Table 1). This framework is established during the Systemic Breakdown phase and forms the structural foundation of the IDEA Design Scaffold. It reflects distinct developmental levels that organize how goal-setting, feedback, learning, and adaptive reorganization of ideas unfold—both across the sociotechnical system and within the design thinking process.

The distinction is methodologically useful for framing complexity: it enables the designer to model which elements interact, at what level of organization, and according to which values or functional norms (Bickhard, 2024). Within this hierarchical structure, interconnected clusters of systemic and design goals—ranging from Operational-Level to MetaSystem-Level (see Table 1 and Figure 2)—can, in principle, guide self-regulatory processes that facilitate the idea development across different levels, timescales (Fujita & Macgregor, 2012) and scopes of systemic transformation.

Systemic Breakdown adopts a top-down approach to navigate sociotechnical challenges, deconstructing abstract design goals into actionable subgoals. This goal construction clarifies overarching systemic objectives while maintaining coherence across systemic levels of abstraction (SL). By aligning interventions with broader societal and ecological priorities, Systemic Breakdown ensures that complexity is made manageable without compromising long-term goals.

This decomposition does not assume linear causality or fixed hierarchies. Instead, Systemic Breakdown enables designers to construct provisional goal structures that organize systemic priorities across abstraction levels. These structures are used to frame emergent dynamics and guide developmental exploration, not to resolve complexity through linear tasks. Linear procedures may occur within a given level, but only after coherence is achieved across the system's goal architecture.

Therefore, Systemic Breakdown methodologically identifies the relevant subset of these lower-level goals—those that form a viable channel of regulation for supporting the higher-level systemic goal. In the IDEAS, these subsets constitute channels of regulation. While these channels can be modeled following a top-down trajectory in a pragmatic sense, they are ultimately emergent within the task environment based on its shifting priorities. In this way, designers can explore how values of sustainability can be achieved in the domain the design challenge is situated, identifying multiple paths of lower-level societal (e.g., safety, well-being, accessibility, public health), and ecological objectives (e.g., biodiversity preservation, resource efficiency, climate adaptation). The logic of this process is further illustrated in the following section (Paths of Deconstruction), which demonstrates how designers can apply this method to align ecological and societal objectives within a design scenario.

Systemic Breakdown as a methodological task is not descriptive in a reductive sense; it is developmental and preparatory, aimed at structuring the designer's subsequent exploration of how systemic goals are currently set and how they might be transformed to channel novelty. By clarifying these inter-level relations, Systemic Breakdown defines in the double diamond (see Figure 2) the scope and structure of ideation in Systemic Integration.

In practice, there are no level limitation in this organized hierarchy, however at the highest level, systemic goals should always reflect the broader orientations, such as sustainability, resilience, or social equity—goals that define the system's long-term direction but do not yet specify how that direction is to be realized.

Paths of Deconstruction

The deconstruction process follows interconnected paths, which guide designers in breaking down abstract goals into actionable subgoals. Figure 3 illustrates this process through two primary paths: the Sustainability Path and the Safety Path, which collectively contribute to the systemic goal of a sustainable, child-centric transportation system.

- **Sustainability Path:** This path prioritizes ecological goals, starting at SL+2 with “reducing carbon emissions.” Designers deconstruct this into SL+1 priorities like “equitable urban energy distribution,” SL operational goals such as “integrating renewable energy systems,” and SL-1 tasks like “designing modular electric shuttles with solar panels.” Proactive feedback loops guide this progression by revealing opportunities to optimize solar-powered networks, while corrective feedback ensures designs meet technical benchmarks for reliability and scalability.
- **Safety Path:** This path emphasizes societal goals such as “ensuring student safety and well-being” (SL+1). Designers break this into SL tasks like “real-time monitoring systems for route safety” and SL-1 tasks such as “child-safe seating and collision avoidance systems.” Feedback loops refine these goals dynamically, addressing discrepancies, such as delays in real-time data processing, to ensure safety protocols align with user needs and systemic objectives.

As shown in Figure 3, these paths are dynamically interconnected. For example, modular shuttles designed to reduce emissions (Sustainability Path) must simultaneously meet safety standards like collision avoidance (Safety Path). The green dashed arrow highlights this interplay, ensuring that solutions are innovative, adaptable, and aligned with societal and ecological priorities.

SL+2: Metasystem Goals

At this level, the goal is to establish a high-level vision for a child-centric, eco-friendly transportation system that aligns with sustainability principles and considers social, safety, and operational needs within the urban context.

SL+1: System Goals

At this level, the goals specify measures that will make the system eco-friendly, safe, and capable of working within the city's existing infrastructure.

SL: Interaction Goals

At this level, the goals specify measures that will make the system eco-friendly, safe, and capable of working within the city's existing infrastructure.

SL-1: Operational Goals

These specific actions directly implement the goals outlined at higher levels, ensuring the system's sustainability, reliability, and safety for students while providing peace of mind to parents.

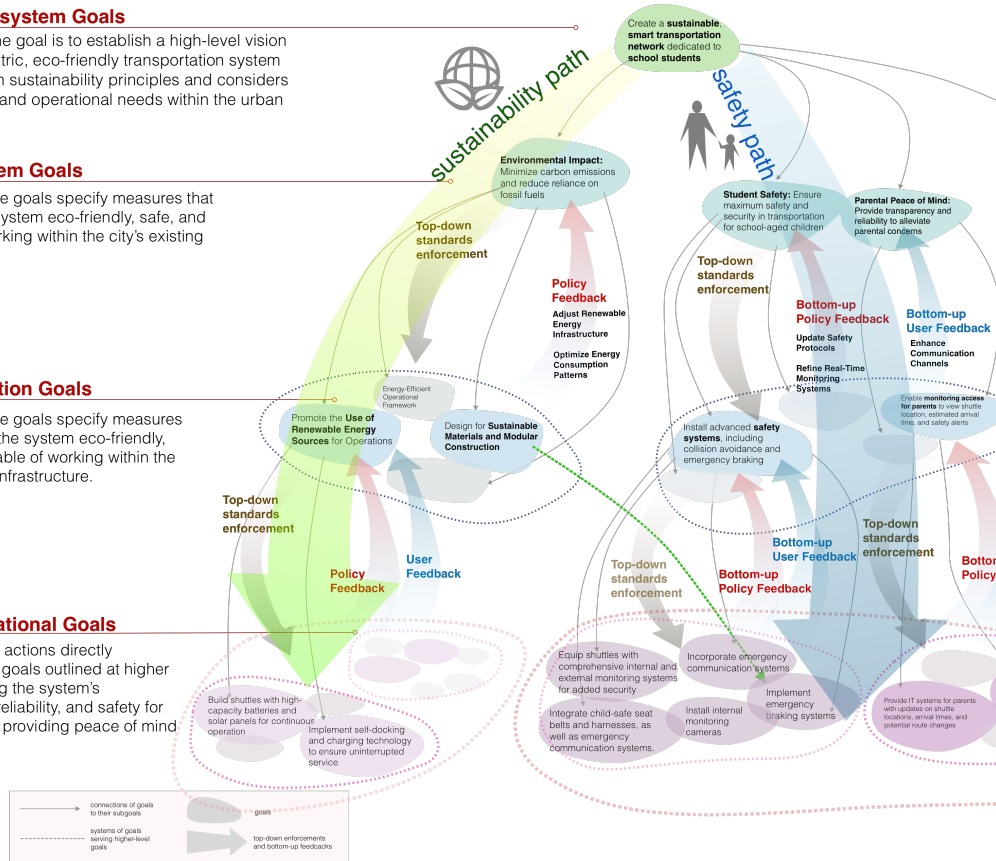


Figure 3 Systemic Breakdown and Integration visualized across interconnected paths. The green dashed arrow highlights how goals and feedback loops between the sustainability and safety paths influence each other, showcasing the dynamic interplay between systemic priorities.

Iterative Adaptation Through Feedback

Corrective (reactive) and proactive (anticipative) feedback loops are central to Systemic Breakdown. They stabilize the entire design trajectory ensuring that design goals remain adaptive and aligned with systemic priorities. Corrective loops compare ideation outcomes against reference values— internal goal conditions that operationalize higher-level priorities—and provide real-time insights for refinement. When discrepancies arise, these loops may prompt the reorganization of design outcomes, the reformulation of goals, or both. Instability in these self-regulatory processes can lead either to the emergence of novelty or to the further stabilization of design direction.

For instance:

- In the Sustainability Path, a reference value might involve “achieving a 50% reduction in carbon emissions.” Proactive feedback during implementation could highlight opportunities to integrate decentralized energy-sharing networks, while corrective feedback addresses challenges like limited grid compatibility.
- In the Safety Path, a reference value such as “ensuring zero incidents during shuttle operations” might reveal gaps in monitoring systems. Corrective feedback loops prompt adjustments, such as optimizing data processing algorithms, ensuring alignment with SL+1 societal priorities.

By fostering iterative reflection, feedback loops refine subgoals dynamically while reinforcing systemic coherence across abstraction levels. Figure 3 visualizes this adaptability, where feedback flows vertically (between levels) and horizontally (across paths), ensuring emerging insights are integrated into design solutions.

Summarizing, Systemic Breakdown equips designers to manage complexity by deconstructing abstract challenges into actionable subgoals guided by interconnected paths. By embedding feedback loops, the Scaffold ensures alignment with societal and ecological priorities, enabling solutions that are both adaptive and transformative. The following section explores Systemic Integration, where these subgoals are synthesized into cohesive interventions aligned with systemic objectives.

Systemic Integration: The Iterative Innovation Cycle (IIC)

Systemic Integration is the methodological core of creative ideation within the IDEA Design Scaffold. It corresponds to what the recursive constructivism defines as the expansion of a space of possibilities through reflective abstraction (Bickhard, 2024). In this developmental framing, ideation does not select from fixed alternatives but reorganizes lower-level interaction affordances into higher-order systemic configurations that generate new goals and possibilities.

These ideation trajectories construct developmental paths—not by optimizing existing interventions, but by enabling the emergence of novel system-level propositions. Rather than applying predefined criteria top-down, the designer works bottom-up: reorganizing affordance structures and value relations into increasingly integrated interventions. This capacity is especially critical in sustainability-focused design. While earlier approaches emphasized artifact-level innovation, systemic transformation requires navigating multiple layers of sociotechnical organization (Ceschin & Gaziulusoy, 2016). Systemic Integration supports this shift by enabling designers to move beyond inherited infrastructures and construct viable pathways toward new ecological and social configurations.

The Iterative Innovation Cycle (IIC) is the methodological backbone of the IDEA Design Scaffold. Enables a recursive modulation of earlier structures—selectively preserved and reorganized through self-scaffolding—even when initially underdeveloped. This mechanism aligns functional scaffolding (Bickhard, 2007): a process in which the designer regulates internal pressures—namely, the intrinsic drive to resolve uncertainty—by constructing intermediate representations (ideas) that are not yet sufficient for resolution but are structurally adequate to support continued development (Xenakis & Arnellos, 2013, 2025). These provisional forms allow designers in constructing, evolving, and stabilizing these ideas across systemic levels of abstraction (SL). So, ideas are not considered here as end states, but partial constructions that anticipate and scaffold the emergence of new design representational capacities.

The IIC integrates divergent (leveling-up) and convergent (leveling-down) thinking dynamically (see Figure 4). Divergent thinking drives the exploration of innovative opportunities, fostering creativity and idea development questioning existing knowledge and assumptions. Conversely, convergent thinking stabilizes these ideas, ensuring coherence with systemic priorities and reference values. Together, these modes provide a structured yet recursive framework for tackling complexity and ambiguity in sociotechnical design contexts. Figure 5 elaborates on this recursive leveling-up process, detailing how designers transition from interaction affordances (SL) to systemic opportunities for interventions (SL+1) and beyond, using stabilization and development trajectories to progress across systemic levels.

Steps of Systemic Integration

The Iterative Innovation Cycle (IIC) operationalizes systemic integration through two iterative steps, advancing ideas across systemic levels and ensuring alignment with broader systemic priorities. This process is visualized in Figure 5, Part B, illustrating the interplay between innovation and development trajectories.

Step 1: From Unstabilized Affordances to Idea Stabilization: This leveling-down process is not the reversal of novelty but its structural prerequisite. Grounding novelty is not merely a definitional criterion of creativity—understood as both novelty and appropriateness (Hennessey & Amabile, 2010) but a developmental necessity. As emphasized in models of reflective abstraction (Campbell & Bickhard, 1986), nothing can be constructed at a given exploratory level unless something already exists at the level just below it to be reorganized. In this view, novelty is not yet functional until it becomes stable, as development proceeds from point of stability to point of stability (Bickhard, 1992).

The IIC begins with perceiving interaction affordances as unstructured, context-sensitive possibilities for design action emerging at SL, grounded in functional requirements and task environment constraints. These affordances initiate divergent trajectories, many of which are unstable or only partially functional (see Figure 4). Through reactive feedback loops, these trajectories are tested against internal reference values and lower-level constraints at SL-1 (see also Figure 1, Part A). When reactive loops fail to stabilize them, these trajectories are suppressed, while others are stabilized at SL-1, forming a viable foundation for further development. These mismatches are not signs of failure but functional signals that trigger reactive learning: they support reconfiguration of subgoals, modulation of reference values, and suppression of affordance trajectories that exceed the system's current viability envelope. This step enables the designer to identify which affordances hold developmental potential and which must be discarded or restructured. In this way, leveling-down is best understood not as the completion of a developmental phase, but as a recursive attempt to reduce uncertainty to the point where ideation can proceed.

For example, in a school transportation system, designers might begin by identifying multiple interaction affordances such as real-time routing, modular seating arrangements, or regenerative braking. These affordances emerge at SL as possibilities grounded in user needs or environmental constraints, but their viability is not yet clear. Through reactive feedback, some of these affordances may prove non-viable—due to cost, complexity, or misalignment with user behavior—and are therefore suppressed. Others may become partially stabilized at SL-1, such as an energy-efficient braking system that consistently meets performance thresholds and integrates smoothly into existing transport infrastructure. This stabilization process provides a structured basis for developmental reorganization in the next phase.

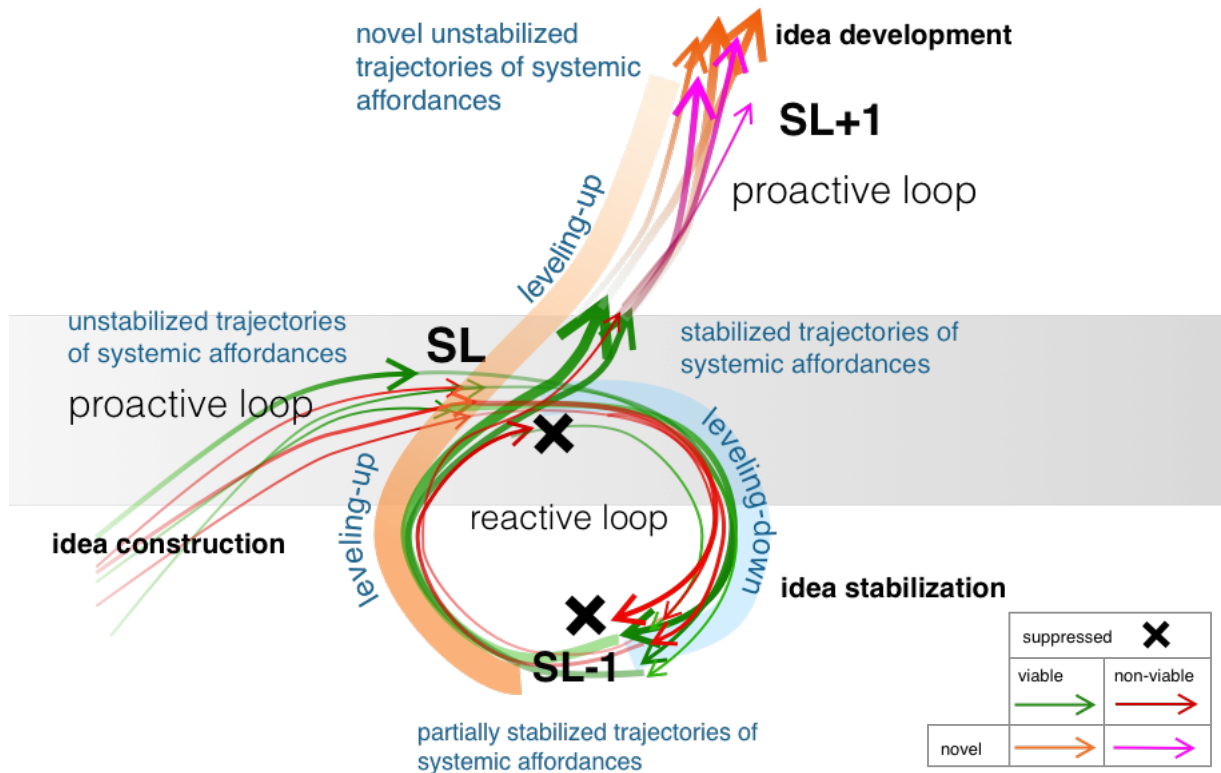


Figure 4 Systemic Integration through recursive feedback loops. Interaction affordances at SL initiate divergent trajectories that undergo reactive stabilization at SL-1. Viable constructs are leveled up through anticipative learning, forming unstable systemic affordances at SL+1. Only those that achieve cross-level coherence stabilize as developmentally viable systemic constructs.

Step 2: Leveling-Up to Systemic Affordances and Developmental Reorganization: Once partially stabilized affordances have emerged at SL-1, designers engage in proactive loops of anticipative learning, projecting how these constructs might fulfill broader systemic priorities, not at the stabilized SL but at the next SL+1. This leveling-up process is not a matter of optimization but of developmental reorganization: it transforms viable interaction affordances into systemic affordances (SysAf) capable of aligning functional feasibility with societal and ecological objectives.

As shown in Figure 4, these emergent constructs are not yet stabilized. They are anticipated to perform novel systemic functions by integrating constraints that govern SL+1, but remain open to modulation, refinement, or rejection. Their coherence must still be tested across levels. At this stage, systemic affordances are structurally novel but developmentally fragile—they initiate a new design trajectory that may lead to stabilization at SL+1 or suppression if misalignment persists.

Once an emergent systemic affordance has begun to exhibit developmental viability, that is, it performs coherent functions at SL+1 while maintaining alignment with stabilized constructs at lower levels (SL), it may serve as the starting point for a new iteration of the IIC. However, this transition is not automatic: it depends on whether the affordance can be stabilized in SL+1 in order to initiate new representational functions aligned with the constraints and reference values of SL+2 (see Figure 5).

For example, in the school transportation context, the idea of shared modular shuttles powered by decentralized solar networks may emerge as a systemic affordance at SL+1, aligning equitable energy distribution (a societal goal) with technical feasibility. This idea, while not yet stabilized at SL+2, begins to express a higher systemic logic—such as supporting a shift toward regenerative and resilient urban mobility ecosystems.

To become a viable construct at SL+2, the designer must engage a new leveling-down cycle—not to implement the idea, but to reorganize it developmentally. This means re-structuring the idea across SL+1 and SL such that it can consistently express SL+2 priorities, like long-term ecological viability, systemic adaptability, or reduced dependency on centralized infrastructure. Only when the construct can maintain coherence across these levels does it stabilize as an SL+2 systemic affordance.

In this way, the IIC enables a recursive, feedback-regulated advancement across levels: each stabilized structure becomes the basis for anticipative exploration at the next level, while each new idea is subjected to realignment pressures from lower-level feasibility and systemic coherence. The cycle supports both innovation and stabilization—not as distinct phases, but as interwoven cognitive functions that allow designers to construct systemic interventions grounded in developmental learning.

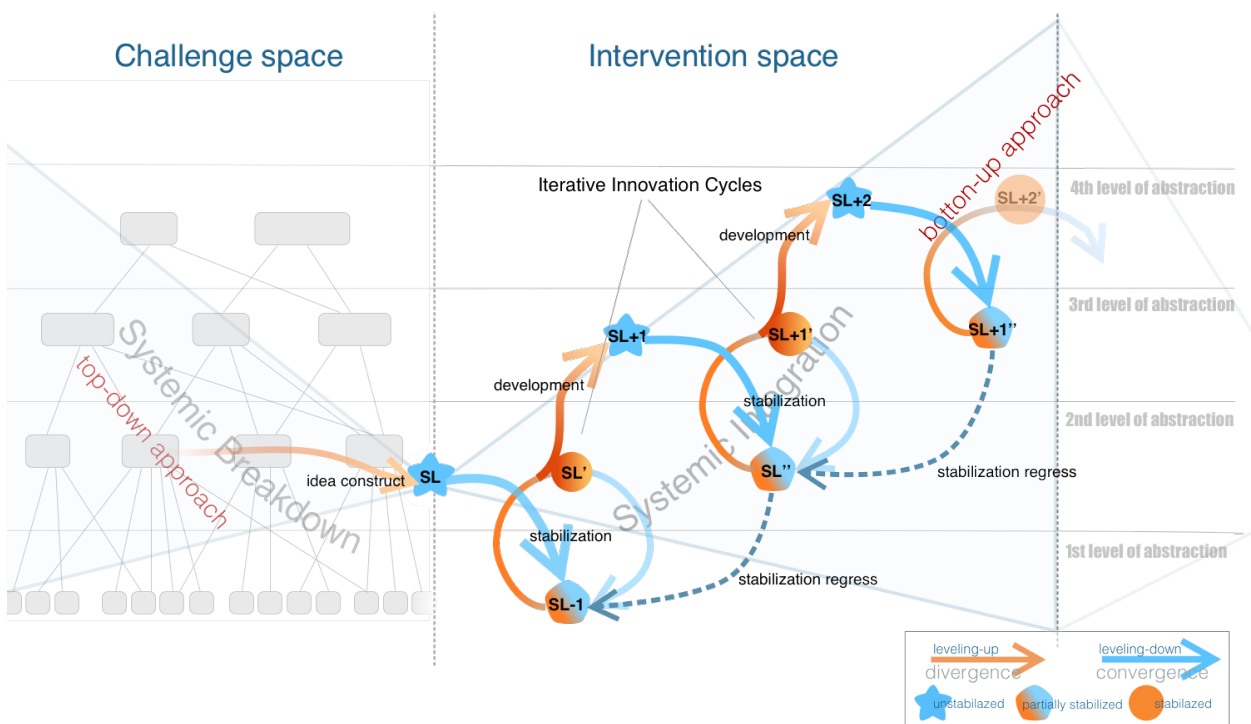


Figure 5 Iterative Innovation Cycles across systemic levels. Systemic Breakdown structures the challenge space through top-down goal modeling, while Systemic Integration develops and stabilizes ideas through bottom-up cycles of divergence and convergence. Each cycle reorganizes constructs across abstraction levels, enabling recursive progression toward systemically viable interventions.

Functional Analysis and Pedagogical Illustration of the Scaffold

While this paper focuses on the theoretical and methodological structure of the IDEA Design Scaffold, its implementation in second-year design studios serves as a contextual illustration of how the framework can be applied in design education. These examples are not intended as empirical validation, but as a means of showing how students engaged with systemic goal-setting, feedback loops, and affordance modeling in structured studio formats.

Pedagogical Illustration and Studio-Based Reflection

The Ideation Studio introduced students to the IDEA Design Scaffold through a sequence of short design tasks, each aimed at building familiarity with systemic thinking. These projects started with low-complexity challenges, allowing students to engage with core systemic principles such as hierarchical goal-setting, feedback loops, and the Iterative Innovation Cycle (IIC). As the semester progressed, the complexity of tasks increased, requiring students to explore SysAf and navigate interconnected goals distributed across abstraction levels.

In these early exercises, students worked through Paths of Deconstruction, such as the Sustainability Path or Safety Path, to translate abstract systemic goals (SL+2) into actionable subgoals at SL and SL-1. For example, students addressing sustainability challenges began with high-level goals like reducing carbon emissions (SL+2). These were translated into SL-level goals, such as integrating renewable energy systems, and SL-1 functional goals, such as designing energy-efficient buses. This process helped students maintain coherence between functional clarity and systemic ambition, aligning conceptual exploration with grounded design interventions.

Studio activities included collaborative mapping sessions, where students visualized systemic goals and traced their interdependencies across systemic levels. This mapping clarified relationships between operational (SL-1), interaction-level (SL), and systemic-level (SL+1) priorities. Students also engaged in identifying interaction affordances within the challenge space and developing preliminary concepts. For example, modular bus designs emerged, emphasizing energy efficiency and adaptability emerged from SL-level exploration. Through reactive feedback loops, these affordances were tested against SL-1 reference values. This evaluative process enabled students to stabilize viable constructs, filtering out misaligned trajectories and refining these ideas before engaging in the developmental reorganization required to construct systemic affordances (SysAf) at SL+1.

The Concept Design Studio extended this learning trajectory to develop stabilized ideas at SL detecting for SysAf that are addressing SL+1 goals, such as urban equity or resource optimization. Students creatively explored how modular bus designs could improve accessibility in underserved communities or how solar-power infrastructure could reduce dependency on centralized systems. These explorations unfolded through the IIC, emphasized recursive ideation, alignment across abstraction levels, and developmental reorganization.

Although IDEAS was the central framework guiding the studio, students also engaged with a range of complementary design methods and tools to support their analysis, ideation, and prototyping processes. These additional methods—while integral to the studio experience—are not detailed here, as the aim of this paper is not to present a comprehensive account of instructional strategies or evaluate tool efficacy. Rather, our purpose is to introduce the IDEA Design Scaffold as a conceptual and methodological framework. Studio projects are included only to illustrate how students interacted with the scaffold's principles—such as hierarchical goal-setting and systemic affordances—within a structured design context.

Reflections on Student Learning

Student reflections underscored both the strengths and challenges of engaging with the IDEAS framework. Many students valued the development of early ideas as tangible entry points for ideation, providing a useful structure for approaching complex challenges. However, some struggled to sustain divergent thinking, often converging prematurely on single idea due to time constraints or reliance on familiar solutions. This tendency limited the exploration of alternative pathways.

The transition from operational goals to broader, systemic opportunities for intervention proved particularly challenging. Students often found these higher-level design opportunities abstract and difficult to define, requiring significant instructor guidance to identify and develop them. Feedback loops were also a key area of both helpful and demanding. While students recognized that corrective and proactive feedback helped improved their ideas they found it difficult to balance feedback from different types of goals especially when practical needs conflicted with broader societal or environmental priorities.

Insights from a questionnaire further supported these observations. Students initially focused on immediate, operational tasks and short-term goals. However, as they progressed through the framework iteratively, many began to recognize and incorporate broader priorities into their design thinking. This shift suggests that IDEAS, helped students begin to engage with systemic perspectives, even as they navigated the cognitive challenges of aligning operational details with complex, long-term objectives. Reflections during studio discussions indicated that structured feedback loops played a key role in supporting this shift, helping students track their ideas evolved and how these ideas aligned with larger priorities.

Instructors noted clear improvements in students' ability to connect operational goals with more abstract design goals as the studio progressed. Iterative engagement appeared to support students in building confidence and navigating the ambiguity inherent in complex design challenges. At the same time, instructors also observed moments of cognitive overload, especially when students had to shift operational tasks and broader systemic considerations. These challenges highlighted the importance of incremental scaffolding to help students gradually develop systemic awareness.

One notable strength of IDEAS was its structured and transparent framework, which was also appreciated by instructors less familiar with ideation theory. Unlike open-ended methodologies, IDEAS offered clear pathways and benchmarks of effectiveness at each stage of ideation. These benchmarks enabled instructors to guide students effectively and evaluate their progress systematically. Even educators without extensive expertise in systemic ideation found the scaffold useful for evaluating students' progress and facilitating learning.

Additionally, instructors observed that the framework's iterative cycles and embedded feedback mechanisms promoted a healthy balance between creative freedom and design rigor. This balance not only benefited students but also gave instructors a tangible mechanism to assess the alignment of design outcomes with systemic priorities, enhancing the overall coherence and efficiency of the studio process.

Challenges and Lessons Learned

While the IDEA Design Scaffold demonstrated its effectiveness in fostering systemic thinking, several challenges emerged during its implementation. The cognitive demands of managing multiple feedback loops and systemic levels often overwhelmed novice designers, particularly during transitions between SL and SL+1. This indicated a need for simplified scaffolding tools and more incremental guidance to help students manage these complexities.

Time constraints in studio settings frequently forced students to truncate iterations, leading to premature convergence on concepts without fully exploring SysAf. Sustaining divergent thinking while progressing toward convergent outcomes was another common challenge, as students often reverted to familiar solutions instead of exploring alternative pathways. These challenges highlight the importance of designing studio timelines that allow for more extensive iterative cycles and integrating structured support mechanisms to encourage exploration.

Despite these challenges, important lessons emerged. Gradually introducing systemic thinking concepts over multiple projects proved effective in helping students internalize the scaffold's principles and build confidence. Structured reflection exercises, including peer critiques and instructor feedback, played a pivotal role in helping students navigate SysAf and refine their interventions iteratively.

Educational Impact

The IDEA Design Scaffold is grounded in recursive constructivist theory and developmental models of self-scaffolding, which frame learning as an active, iterative reorganization of understanding. Within this framework, IDEAS supports novice designers not only methodologically but also educationally, offering a learning-oriented pathway through which students develop an understanding of how novel knowledge is constructed as they engage with complex and uncertain design challenges.

By framing systemic thinking and innovation as a developmental process, the scaffold facilitates learning as a natural progression. Students engaged with paths of deconstruction, feedback loops, and systemic affordances to navigate sociotechnical complexity. These activities provided opportunities to explore interdependencies, refine problem representations, and align functional goals with broader societal and ecological priorities. Through this structured engagement, the scaffold helped students develop a systems-oriented mindset capable of addressing multi-layered design problems.

Looking ahead, future iterations of the scaffold will focus on addressing cognitive overload through simplified entry points, enhancing feedback mechanisms, and integrating emerging technologies like AI-driven tools to visualize systemic interdependencies. These refinements aim to make IDEAS more accessible and impactful, preparing the next generation of designers to tackle global challenges with systemic and sustainable solutions.

Acknowledgements: The research work has been supported by the Project: GRANT AGREEMENT NUMBER 101094998 — HERITACT — HORIZON-CL2-2022-HERITAGE-01

References

- Amabile, T. M., & Pratt, M. G. (2016). The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning. *Research in Organizational Behavior*, 36, 157–183.
<https://doi.org/10.1016/j.riob.2016.10.001>
- Azevedo, R., & Hadwin, A. F. (2005). Scaffolding self-regulated learning and metacognition – Implications for the design of computer-based scaffolds. *Instructional Science*, 33(5/6), 367–379.
- Banathy, B. H. (1996). *Designing Social Systems in a Changing World*. Springer US. <https://doi.org/10.1007/978-1-4757-9981-1>
- Bickhard, M. H. (1992). Scaffolding and Self-scaffolding: Central aspects of development. In L. T. Winegar & J. Valsiner (Eds.), *Children's Development Within Social Context* (Vol. 2, pp. 33–52). Lawrence Erlbaum Associates Publishers.
- Bickhard, M. H. (2005). Functional scaffolding and self-scaffolding. *New Ideas in Psychology*, 23(3), 166–173.
<https://doi.org/10.1016/j.newideapsych.2006.04.001>
- Bickhard, M. H. (2007). Learning is Scaffolded Construction. In D. W. Kritt & L. T. Winegar (Eds.), *Education and Technology* (pp. 73–88). Rowman & Littlefield.
- Bickhard, M. H. (2024). *The Whole Person: Toward a Naturalism of Minds and Persons* (1st ed.). Academic Press.
- Bunge, M. (2014). *Emergence and Convergence: Qualitative Novelty and the Unity of Knowledge* (Reprint). University of Toronto Press.
- Campbell, R. L., & Bickhard, M. H. (1986). *Knowing levels and developmental stages* (Vol. 16). Karger.
- Carver, C. S., & Scheier, M. F. (2012). Cybernetic Control Processes and the Self-Regulation of Behavior. In R. M. Ryan (Ed.), *The Oxford Handbook of Human Motivation* (Illustrated edition, pp. 28–42). Oxford University Press.
- Carver, C. S., & Scheier, M. F. (2017). Self-Regulatory Functions Supporting Motivated Action. In A. J. Elliot (Ed.), *Advances in Motivation Science* (pp. 1–37). Elsevier. <https://doi.org/10.1016/bs.adms.2017.02.002>
- Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies*, 47, 118–163. <https://doi.org/10.1016/j.destud.2016.09.002>
- Christensen, W. D., & Hooker, C. A. (2000). An interactivist-constructivist approach to intelligence: Self-directed anticipative learning. *Philosophical Psychology*, 13(1), 5–45. <https://doi.org/10.1080/09515080050002717>
- Csikszentmihályi, M. (1988). Motivation and creativity: Toward a synthesis of structural and energistic approaches to cognition. *New Ideas in Psychology*, 6(2), 159–176. [https://doi.org/10.1016/0732-118X\(88\)90001-3](https://doi.org/10.1016/0732-118X(88)90001-3)

- Design Council. (2022). *The Double Diamond: 15 years on*. <https://www.designcouncil.org.uk/our-work/news-opinion/double-diamond-15-years/>
- Dubberly, H., & Pangaro, P. (2023). How Might We Help Designers Understand Systems? *She Ji: The Journal of Design, Economics, and Innovation*, 9(2), 135–156. <https://doi.org/10.1016/j.sheji.2023.05.003>
- Feldman, D. H. (1989). Creativity: Proof that development occurs. In W. Damon (Ed.), *Child development today and tomorrow* (pp. 240–260). Jossey-Bass.
- Fujita, I., & Macgregor, K. E. (2012). Basic Goal Distinctions. In H. Aarts & A. J. Elliot (Eds.), *Goal-directed Behavior* (pp. 85–114). Psychology Press, Taylor & Francis Group.
- Hennessey, B. A., & Amabile, T. M. (2010). Creativity. *Annual Review of Psychology*, 61(1), 569–598. <https://doi.org/10.1146/annurev.psych.093008.100416>
- Hooker, C. A. (1994). Regulatory constructivism: On the relation between evolutionary epistemology and Piaget's genetic epistemology. *Biology and Philosophy*, 9(2), 197–244. <https://doi.org/10.1007/BF00857932>
- Hui, A. N. N., He, M. W. J., & Wong. (2019). Understanding the Development of Creativity Across the Life Span. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativity* (2 edition, pp. 69–87). Cambridge University Press.
- Jones, P. (2014). Systemic Design Principles for Complex Social Systems. In G. S. Metcalf (Ed.), *Social Systems and Design* (pp. 91–128). Springer Japan. https://doi.org/10.1007/978-4-431-54478-4_4
- Meadows, D. H. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing.
- Midgley, G. (2000). *Systemic Intervention: Philosophy, Methodology, and Practice* (1st ed.). Springer US.
- Norman, D. A., & Stappers, P. J. (2015). DesignX: Complex Sociotechnical Systems. *She Ji: The Journal of Design, Economics, and Innovation*, 1(2), 83–106. <https://doi.org/10.1016/j.sheji.2016.01.002>
- Sevaldson, B. (2022). *Designing Complexity: The Methodology and Practice of Systems Oriented Design*. Common Ground Research Networks.
- Simonton, D. K. (2000). Creative Development as Acquired Expertise: Theoretical Issues and an Empirical Test. *Developmental Review*, 20(2), 283–318. <https://doi.org/10.1006/drev.1999.0504>
- Sternberg, R. J. (2003). The Development of Creativity as a Decision-Making Process. In R. K. Sawyer (Ed.), *Creativity and Development*. Oxford University Press.
- Tuunanen, Tuure, Winter, R., & Brocke, Jan vom. (2024). Dealing with Complexity in Design Science Research: A Methodology Using Design Echelons. *MIS Quarterly*, 48(2), 427–458.

- van der Bijl-Brouwer, M. van der, & Malcolm, B. (2020). Systemic Design Principles in Social Innovation: A Study of Expert Practices and Design Rationales. *She Ji: The Journal of Design, Economics, and Innovation*, 6(3), 386–407. <https://doi.org/10.1016/j.sheji.2020.06.001>
- Weisberg, R. W. (1999). Creativity and Knowledge: A Challenge to Theories. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 226–250). Cambridge University Press.
- Xenakis, I. (2025). Naturalizing aesthetic learning and development in creative explorations: An Interactivist-Constructivist Model of Aesthetics. *Syzetesis*, (in press).
- Xenakis, I., & Arnellos, A. (2013). The relation between interaction aesthetics and affordances. *Design Studies*, 34(1), 57–73. <https://doi.org/10.1016/j.destud.2012.05.004>
- Xenakis, I., & Arnellos, A. (2014). Aesthetic perception and its minimal content: A naturalistic perspective. *Frontiers in Psychology*, 5(1038). <https://doi.org/10.3389/fpsyg.2014.01038>
- Xenakis, I., & Arnellos, A. (2025). Relating creativity to aesthetics through learning and development: An Interactivist-Constructivist framework. *Phenomenology and the Cognitive Sciences*. <https://doi.org/10.1007/s11097-025-10084-5>
- Yelland, N., Cope, B., & Kalantzis, M. (2008). Learning by Design: Creating pedagogical frameworks for knowledge building in the twenty-first century. *Asia-Pacific Journal of Teacher Education*, 36(3), 197–213. <https://doi.org/10.1080/13598660802232597>

About the Authors

Ioannis Xenakis is Assistant Professor of Design Thinking and Functional Ideation at the University of the Aegean. His research integrates systemic design, cognitive aesthetics, and interaction theory to examine how perceptual, emotional, and developmental processes shape functional ideation in complex sociotechnical systems. He draws on embodied cognition, complex systems theory, constructivist learning, and cognitive theories of aesthetics.

Despina Grigoreli is a PhD candidate in Creative Ideation at the University of the Aegean. Her research integrates systemic thinking, complex systems theory, and creative problem-solving to address the complexity and uncertainty of sociotechnical challenges, focusing on developing methodological tools that support designers in navigating complexity and generating functional interventions. She draws on systems theory, functional creativity, and social innovation design.