

MAPPING KNOWLEDGE INTEGRATION CHALLENGES IN PARTICIPATORY AND CO-DESIGN PROCESSES: TOWARDS A DESIGN KNOWLEDGE INTEGRATION SPECTRUM

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ABSTRACT

Participatory and co-design approaches have been widely recognized for enabling collaboration between designers and non-designers. However, despite their emphasis on shared creativity and co-creation, existing frameworks often offer limited explanations of how diverse forms of knowledge are identified, exchanged, and integrated throughout the design process. This paper presents a critical review of recent participatory and co-design studies to examine how knowledge integration is conceptualized and operated within contemporary design research. Building upon Sutcliffe and Sawyer's (2013) classification of knowledge into known knowns, known unknowns, and unknown unknowns, this study analyses how these categories are implicitly addressed within the design frameworks. The findings suggest that current design approaches primarily focus on the first two types of knowledge, while largely neglecting strategies that enable the emergence of the knowledge that cannot be acknowledged from existing experience. To address this gap, the paper proposes the Design Knowledge Integration Spectrum, to map these epistemic boundaries and guide knowledge activation in design practices.

Keywords: Design process, knowledge integration, knowledge activation, codesign, participatory design

1 INTRODUCTION

Co-design has evolved from a workplace democratic initiative into a core system for addressing complex challenges in engineering and product development [1]. The shift from "designing for users" to "designing with users" requires integrating collective knowledge from various disciplines and stakeholders [2]. However, A significant portion of co-design research remains focused on addressing "known knowns"(knowledge derived from the observer's existing experience) and "known unknowns"(knowledge that the observer can recognize as potentially existing, but which belongs to others). In these cases, designers often work within established frameworks to find surface-level needs or use brainstorming to fill predictable gaps [1], which limits the potential for product innovation. Thus "Unknown Unknown Knowledge" is essential, which is defined as knowledge that the observer, based on their existing experience, is entirely unable to foresee or realize [3].

Design is not just about solving existing problems; it is a process of exploration that deals with high levels of uncertainty [4]. Traditional user-centred design (UCD) often treat users only as sources of information, which only captures explicit "known" data. Because of differences in background and power between stakeholders, "Unknown Unknown Knowledge"—which is often hidden in deep cultural contexts or outside of daily routines—cannot be activated [5]. These gaps in knowledge can lead to inefficient solutions and make co-design a procedural formality rather than a generative collaboration [6].

Addressing this challenge, design education should go beyond teaching form-giving or user research tools; it should focus on managing collaboration and understanding user perspectives [7]. The essential goal is the construction of user knowledge on the designer-side. To bridge these existing design cognitive gaps, this research introduces the "Design Knowledge Integration Spectrum." This model is a cognitive tool for identifying and activating different types of knowledge during the early stages of product development. It helps teams move systematically from "Known Knowns" to "Unknown Unknowns." By proposing this tool, this paper aims to provide a new way for design education to use collective creativity to address complex social and technical challenges.

2 METHODOLOGIES

2.1 Research approach

This study employs a bibliometric analysis approach using CiteSpace (version 6.4.R1) to examine the evolution and knowledge structure of co-design and participatory design. This quantitative method was chosen to provide an objective, macro-level perspective that complements traditional qualitative reviews by visualizing large-scale citation data and identifying key shifts within the field.

2.2 Data collection and refinement

The data were retrieved from the Web of Science (WoS) Core Collection. To ensure relevance, the search was limited to five major journals: *Design Studies*, *Design Issues*, *Design Journal*, *International Journal of Design*, and *CoDesign*.

The search string is: "participatory design OR co-design OR codesign OR co-creation OR cocreation". The search was limited to "Topic" and restricted to "Article OR Review" types. After filtering, 722 valid documents were obtained, spanning from June 2004 to December 2025.

2.3 Bibliometric mapping and analysis

The analysis followed a dual mapping process to identify both research hotspots and theoretical foundations.

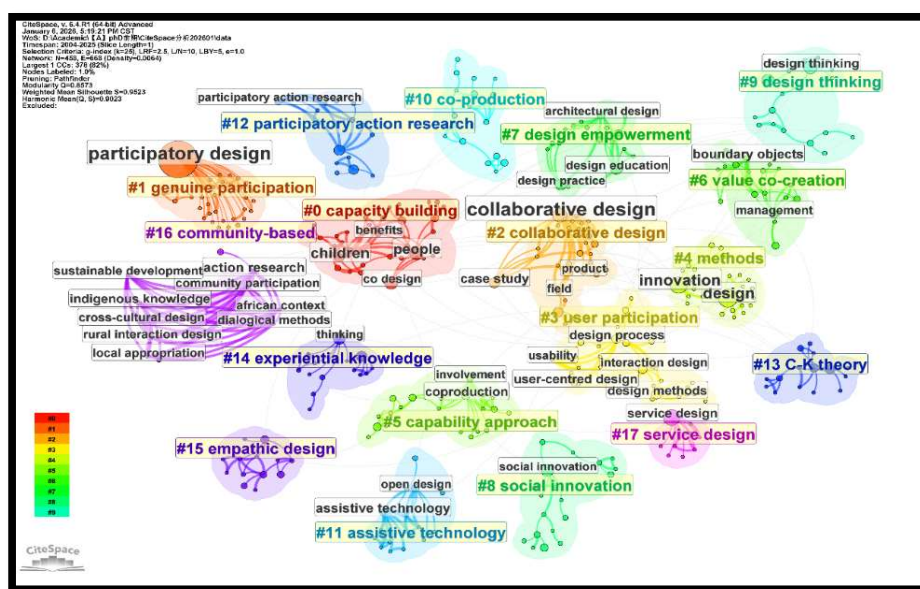


Figure 1. Keyword co-occurrence cluster map

Figure 1 represents the thematic segmentation of the field, identifying core research nodes such as social innovation, capability building, and experiential knowledge. These clusters demonstrate a transition in research focus from instrumental #4 *methods* and #17 *service design* toward more complex social and cognitive dimensions, such as #8 *social innovation*, #13 *C-K theory*, and #14 *experiential knowledge*. The dense interconnectedness of these nodes illustrates how co-design has expanded from a technical process into a multidisciplinary paradigm concerned with #7 *design empowerment* and #10 *co-production*.

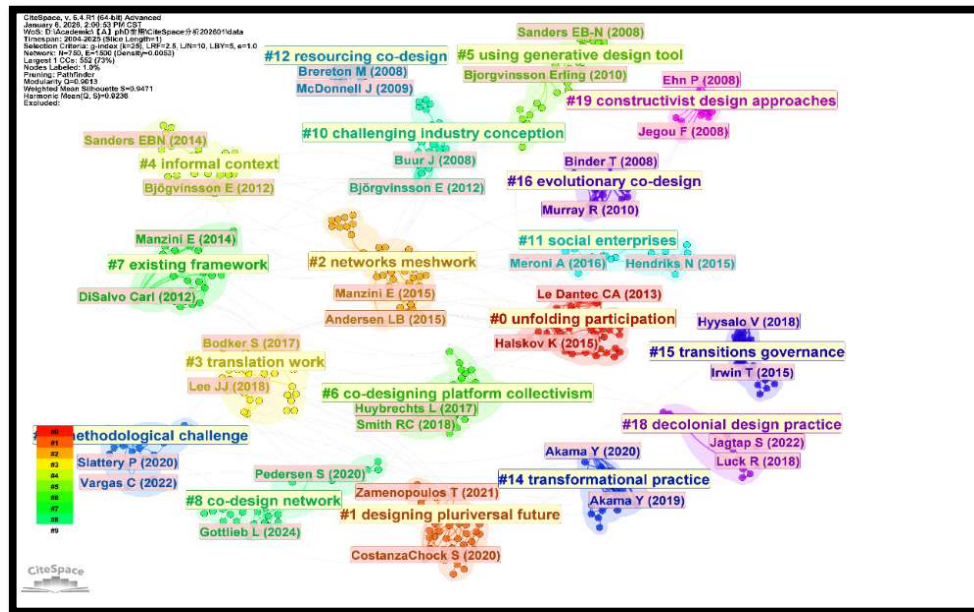
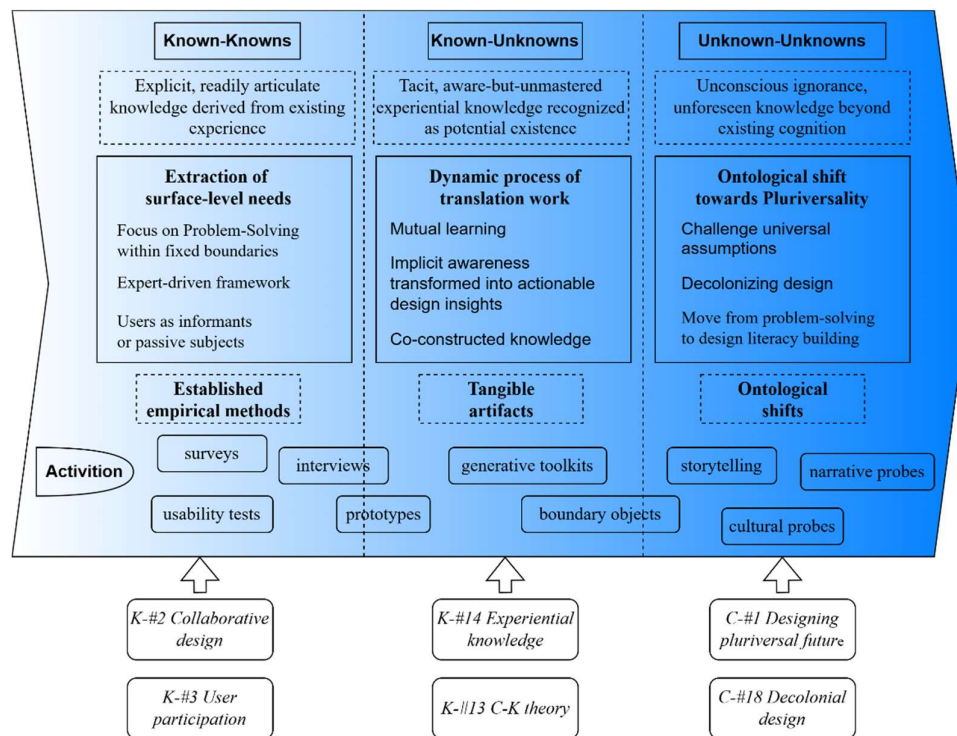


Figure 2. Document co-citation cluster map

Figure 2 illustrates the distribution of key theoretical frameworks, highlighting the prominence of constructivist approaches and recent shifts toward pluriversal and decolonial design practices. Key clusters such as #0 *unfolding participation*, #3 *translation work*, and #5 *using generative design tools* represent the field's established constructivist basis. More significantly, the map reveals a recent peripheral expansion toward radical frontiers, represented by #1 *designing pluriversal future* and #18 *decolonial design practice*.

3 THE DESIGN KNOWLEDGE INTEGRATION SPECTRUM



Clusters derived from the bibliometric analysis

Figure 3. The Design Knowledge Integration Spectrum

Bibliometric analysis reveals a lack of a guiding framework to assist design researchers and educators in identifying diverse knowledge types within collaborative design processes and providing corresponding activation actions. Building upon Sutcliffe and Sawyer's classification of knowledge [3], this study proposes the Design Knowledge Integration Spectrum (Figure 3). As illustrated, this spectrum is developed from the clustering results of the bibliometric analysis. The deployment of a "spectrum" as the representational modality for this framework is predicated on two reasons. First, the design knowledge integration process is a continuous progression rather than a linear workflow composed of discrete, encapsulated steps. Second, design knowledge types and the activation mechanisms involved in the integration process do not share the same solid boundaries. This fluidity is demonstrated by the various activation mechanisms traversing the dashed lines in the diagram.

3.1 Known-Knowns: Extraction of surface-level needs

At the initial segment of the spectrum, co-design focuses on Known-Knowns. As shown in Figure 3, this stage is characterized by a focus on problem-solving within fixed boundaries, utilizing an expert-driven framework where users serve as informants or passive subjects [2]. According to the bibliometric results, this domain is represented by Keyword Cluster #2 *Collaborative design* and Keyword Cluster #3 *User participation*.

At this level, designers use established methods. While this approach is efficient for capturing known variables and meeting basic requirements, it stays within the limits of expected user needs. It often fails to overcome cognitive boundary to explore knowledge beyond what they already know, which limits the potential for significant innovation [9].

3.2 Known-Unknowns: Dynamic process of "translation work"

As collaboration deepens, the domain of Known-Unknowns. This stage is identified as a dynamic process of "translation work", where implicit awareness is transformed into actionable design insights through mutual learning and co-construction. This phase corresponds to Keyword Cluster #14 *Experiential knowledge* and Keyword Cluster #13 *C-K theory*.

To activate this knowledge, designers use "boundary objects" such as prototypes [10]. These objects act as supports that allow non-designers to show their hidden needs and experiences in a shared space. Theory like Concept-Knowledge (C-K) theory provides a logical way to explain this process by showing the interaction between established knowledge and the exploration of new concepts [11]. In this part of the spectrum, knowledge is not just transferred from the user to the designer; it is co-constructed through shared work [12].

3.3 Unknown-Unknowns: Ontological shift towards Pluriversality

At the end of the spectrum, co-design deals with "Unknown Unknowns", which is represented by Co-citation Cluster #1 *Designing pluriversal future* and Co-citation Cluster #18 *Decolonial design*.

Research in these clusters challenges the standard ways of thinking that often dominate design. Scholars argue that traditional design methods can ignore the different ways of knowing held by marginalized or local communities, making this knowledge invisible. To find this hidden information, researchers suggest a shift toward "pluriversal design," [19] which means designing for a world where many different viewpoints can exist together.

Accessing these Unknown Unknowns requires to create "safe spaces", in which power is shared more equally, allowing different or marginalized stories to be heard without pressure to follow standard design logic [13]. By using methods like storytelling and cultural probes, participants are encouraged to question their basic assumptions [14]. This openness helps teams move past their usual habits and find unexpected knowledge, allowing communities to redefine their problems and create new, transformative futures.

4 DISCUSSIONS: IMPLICATIONS FOR DESIGN EDUCATION

4.1 Enhancing design literacy through knowledge activation

The Spectrum provides an assessment tool for design education. Traditionally, design education evaluates students on their ability to collect and organize explicit user requirements—the "Known Knowns" [2]. To improve design literacy, educators should focus on how students identify and activate tacit, unarticulated experiences, which represent "Known Unknowns" [15].

This change in teaching requires assessing students on their ability to create and use physical tools, such as prototypes and boundary objects [16]. In a collaborative setting, prototypes are more than early versions of a final product; they act as physical supports that allow non-designers to show their hidden needs in a shared space. Therefore, educators should evaluate students on how well they use these objects to support shared learning and uncover hidden knowledge among different stakeholders, rather than just judging the technical details of the final product [17]. Subsequent to this stage, students should be directed towards the exploration of "Unknown Unknowns" via approaches like cultural probes, facilitating a further enhance of design literacy.

4.2 Navigating uncertainty

As co-design moves into the "Unknown Unknowns" phase, design education must actively prepare students to manage high levels of uncertainty and conflicting viewpoints [18]. To manage this uncertainty, students must learn to move away from using only standardized or one-size-fits-all solutions. They need to recognize and integrate different worldviews [19]. This requires being ready for unexpected changes. By learning to tolerate uncertainty and working through the disorganized early stages of a design project, students can move past their current cognitive limits [20]. Developing this tolerance for the unknown is essential for creating physical products that address deep social complexities rather than just fixing superficial issues. More fundamentally, design education needs to purposely foster an appreciation for diversity among students; this requirement exists because pluriversal and decolonial lenses tend to elicit deeper uncertainties.

4.3 Building facilitation and collaboration skills

To achieve these levels of knowledge integration, design education must help students change their professional identity from an "expert" who gives orders to a "facilitator" who supports collaboration. Traditional training can sometimes lead to an expert-centred approach where the professional acts as the only creative lead. Instead, students must develop sensitivity to the social and emotional aspects of working in a diverse team [21].

Students need to learn how to build "safe spaces" [13] so that participants without a design background feel secure and valued. By practicing active listening and sharing decision-making power, students can empower others to become active co-creators. This change in teaching ensures that future designers move beyond surface-level participation and achieve genuine shared knowledge creation, leading to more responsible design results. Guided by the Design Knowledge Integration Spectrum, the directional focus of design education is clearly shown. Within the collaborative and participatory design context, the primary goal of design pedagogy is to foster students' ability to construct their own design knowledge for their own design practice, rather than the passive replication of established knowledge transferred from educators and users.

5 CONCLUSION AND REFLECTIVE PRACTICE

This paper has traced the development of knowledge integration in co-design by analysing five major journals published between 2004 and 2025. The findings show that co-design has moved from being a simple set of tools to becoming a complex social and cognitive system. To help practitioners and educators manage this complexity, this study introduced the "Design Knowledge Integration Spectrum", for navigating the cognitive boundaries between explicit, tacit, and unforeseen knowledge. The bibliometric analysis confirms that while the field has mastered the extraction of surface-level needs through collaborative design and user participation, it must now embrace the radical frontiers of pluriversal and decolonial design to activate the most hidden dimensions of knowledge.

The results of this study have important implications for design education and product development. This research provides a view shift that encourages design educators to move from a focus on the final product to a focus on knowledge integration. By using the "Design Knowledge Integration Spectrum," educators can prioritize developing students' skills in collaboration and managing uncertainty. Ultimately, this approach improves the design literacy of both future designers and even other non-designers involved into the whole design process, helping them co-create knowledge and solve the complex design problems of the modern world.

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