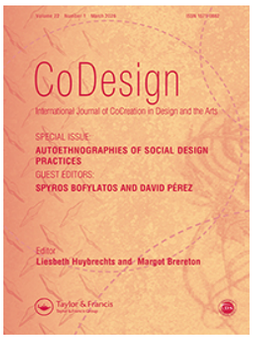

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Disentangling collaborative design for sustainability

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ABSTRACT

The relationship between collaborative design (CD) and design for sustainability (DfS) is an emerging focus in design literature, driven by the urgency of the environmental crisis. Historically perceived as driving consumption, designers are increasingly recognised as critical actors in sustainability initiatives. Based on a scoping review, this study investigates the connections and relationships between CD and DfS with the aim of understanding the interrelations between these two themes. Adopting a tailored scoping strategy, the authors developed a dataset of publications from design journals indexed in Scopus and extracted relevant excerpts (i.e. rich quotes). The rich quotes were analysed thanks to activity theory and statement card analysis, resulting in the Collaborative Design for Sustainability framework. Based on the activity system, this framework provides a structured approach for practitioners to integrate diverse perspectives, emphasising the importance of systemic thinking in collaborative sustainability efforts. The paper also highlights limitations in existing literature, particularly around methods for operationalising collaboration, and calls for further research to apply the proposed framework in practical and educational contexts to enhance collaborative practices for sustainability.

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Collaborative design for sustainability; design for sustainability; collaborative design; activity theory; statement card analysis

1. Introduction

For decades, designers have been perceived as creative professionals promoting the consumption of new materials, products, and experiences. They were seen as 'agents for unsustainable patterns of existence' (Kendall and Dearden 2020, 92). Designers had to navigate different values and economic contexts to practise their profession without full recognition. Over the last few years, design associations like the Design Council and World Design Organization have communicated the strengths and power of design to shape our future. In the present environmental context that seeks immediate actions and changes, design for sustainability is increasingly becoming a *sine qua non* for designing. Therefore, as stated by Leal et al. 'design is going through a process of change as it tries to identify opportunities to cooperate and help solve societies' most complex issues' (2022, 54). Accordingly, competency frameworks around sustainable development (e.g. Bianchi et al. 2022) suggest several design

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competencies are essential for advancing durable, innovative ideas, such as the designer's ability to deal with uncertainties, flexibility and adaptability in continuously evolving situations, the capacity to consider multiple perspectives, and for creative and prospective thinking (Bucciarelli 1988; Lawson and Dorst 2009; McDonnell 2015). Also, collaborative competencies might be one asset through which designers can contribute to transforming the world into a more sustainable one. The study is the authors' first exploration of the relationship between collaboration and sustainability in design literature. The aim is to understand how the interrelation between these broad topics (and often buzzwords) has been framed thus far and encourage further studies, discussions and reflections on the question within the community. The following two definitions ensure a shared comprehension of both concepts.

- **Collaborative design (CD)** is a process that involves the efforts and perspectives of multiple actors – designers, other stakeholders – towards a joint outcome. Shared goals are enhanced through task interdependency, communication and shared understanding. The project evolves concurrently with the exchange of individual perspectives and collective knowledge construction (Tessier 2020). This definition emphasises the process's collaborative nature – distinct from coordination, cooperation, participation – without a specific connotation to the people taking part in the process with the designers nature – e.g. participatory design, codesign, multi/inter/transdisciplinary design.
- **Design for sustainability (DfS)** is a process that involves designing using approaches and envisioning strategies that seek to value ecological, social, and economic considerations in the design process (Ceschin and Gaziulusoy 2019; D'Itria, Pei, and Bertola 2024). Formerly based on Brundtland's widely known rationale of meeting 'the needs of the present without compromising the ability of future generations to meet their own needs' (UN Secretary-General and World Commission on Environment and Development 1987, 16), design for sustainability now benefits from complementary, more radical perspectives. Newer philosophies consider additional dimensions, such as the ethics and politics of human relations with the environment and efforts to sustain nature, which should take precedence over market or consumer demands (Fry 2009). Over time, sustainability thinking and its related terminology have evolved from minimising environmental harm to more systematic, circular, and regenerative approaches (Reed 2007) to encourage design as an active 'redirective practice' to reach a collective state of 'sustain-ability' (Fry 2009).

The scoping review examines how collaboration and sustainability are interrelated in design literature. Acknowledging that various definitions and perspectives of CD or DfS exist, this study does not seek to define nor compare them; it aims to identify how sustainability elements are framed and reported concerning collaborative design activities and vice versa. The results shared in this paper have been structured to explain how the study was conceived and collaboratively developed and what we learned from it. The paper presents the scoping process nature. Moreover, a framework based on activity theory (AT) was combined with the statement card

analysis to frame the results. These methods allowed for contextualising the activity system components of Collaborative Design for Sustainability and synthesising them in an activity system.

2. Method for the scoping process

Scoping reviews are a well-suited methodology for exploring emerging or underexamined topics, providing a broad overview and identifying gaps that warrant further investigation (Arksey and O'Malley 2005), by integrating ideas and perspectives from multiple authors across different times and locations. A literature corpus is analysed through scoping to clarify concepts, investigate existing research, and identify knowledge gaps (Munn et al. 2018). To develop the scoping review, we adopted a nested approach that integrates a scoping review with an Activity Theory (AT) framework. This process involves five key stages: (1) identifying the research question; (2) identifying relevant studies; (3) selecting the studies; (4) charting the data; (5) collating, summarising and reporting the result (Arksey and O'Malley 2005). The optional expert consultation step has been omitted due to limited resources and given the domain expertise of the two researchers involved. Our methodology follows a nested approach, combining a scoping review with AT as a theoretical lens. Acknowledging the limitation of relying on a single framework, we complemented AT with the statement cards method, allowing for a more nuanced analysis and a further interpretative layer.

2.1. Identifying the research question

The research stemmed from our established interest in collaborative practices in design education(see (Mattioli 2022; Tessier 2021) and from a growing shared focus on design for sustainability. Hence, the scoping process aimed at understanding how design activities were framed by other scholars at the intersection of collaborative design (CD) and design for sustainability (DfS). We included studies explicitly linking both concepts and those primarily addressing either CD or DfS, and marginally the other. More specifically, the analysis of the existing literature aimed to make the following emerge: *i*) the elements characterising the design activities described in the literature and explicitly connected by the authors to both CD and DfS and *ii*) the interconnection between these elements.

2.2. Identifying relevant studies

Bibliographic data were gathered via Scopus to initiate the scoping process. To include studies explicitly linking both CD and DfS, we identified two keyword groups linking sustainability (e.g. sustainab*, eco-design, eco-innovation, circular, industrial transformation and variants) and collaboration (e.g. cooperat*, coordinat*, collaborat*, codesign and variants). Various queries were tested to reach a satisfying number of publications (see Table 1). The first search aimed to identify publications containing at least one keyword per group in their title, abstract or keywords and provided more than 100.000 results across all the indexed domains. The keyword 'design' was added to the previous filters to get a more focused set: the result was still

Table 1. Query used in the Scopus search for the scoping process. The dataset was retrieved in December 2023. The columns relating to search results in April 2023 and July 2024 show how the number of publications grew while the study was being conducted.

	Query string	Resulting documents		
		5 April 2023	31 December 2023	23 July 2024
First query	TITLE-ABS-KEY (('sustainab*' OR 'eco design' OR 'eco-design' OR 'eco-innovation' OR 'eco innovation' OR 'circular*' OR 'industrial transformation') AND ('cooperat*' OR 'coordinat*' OR 'collaborat*' OR 'codesign' OR 'codesign' OR 'co design'))	93 720	106 323	115 768
Second query	TITLE-ABS-KEY (('sustainab*' OR 'eco design' OR 'eco-design' OR 'eco-innovation' OR 'eco innovation' OR 'circular*' OR 'industrial transformation') AND ('cooperat*' OR 'coordinat*' OR 'collaborat*' OR 'codesign' OR 'codesign' OR 'co design')) AND ('design')	36 843	45 521	47 496
Thrid query	TITLE-ABS-KEY (('sustainab*' OR 'eco design' OR 'eco-design' OR 'eco-innovation' OR 'eco innovation' OR 'circular*' OR 'industrial transformation') AND ('cooperat*' OR 'coordinat*' OR 'collaborat*' OR 'co-design' OR 'codesign' OR 'co design')) AND (EXACTSRCTITLE ('Design Issues' OR 'Design Studies' OR 'codesign' OR 'International Journal of Design' OR 'Design Journal' OR 'She Ji')) AND (LIMIT-TO (EXACTSRCTITLE, 'Design Journal') OR LIMIT-TO (EXACTSRCTITLE, 'codesign') OR LIMIT-TO (EXACTSRCTITLE, 'Design Studies') OR LIMIT-TO (EXACTSRCTITLE, 'She Ji') OR LIMIT-TO (EXACTSRCTITLE, 'International Journal Of Design Education') OR LIMIT-TO (EXACTSRCTITLE, 'International Journal of Design') OR LIMIT-TO (EXACTSRCTITLE, 'Design Issues'))	71	77	80

more than 40.000 publications. In the third query, the keyword 'design' was substituted by a filter to consider a set of design journals indexed in Scopus (i.e. Codesign, Design Issues, Design Studies, International Journal of Design, International Journal of Design Education, The Design Journal, She Ji). While somewhat arbitrary and potentially limiting, this strategy effectively targeted relevant scientific publications. The query yielded 77 publications (see Table 1), forming the initial dataset whose metadata was stored.

2.3. Selecting the studies

Each publication's relevance was assessed by reviewing the abstracts to ensure both CD and DfS were explicitly mentioned in the paper, as the goal was to find papers to understand their interrelations better; 45 publications were included, and 32 were excluded. Lastly, to complement the dataset with potentially relevant studies, the primary literature reference lists were cross-examined using Research Rabbit (i.e. an AI app for literature reviews) and included the most cited related work. We obtained a final collection of 47 publications.

2.4. Organizing extracted data

Three qualitative coding cycles were performed using MAXQDA to refine our understanding of the data; each cycle followed guidelines developed by the team. In the first coding cycle, the passages related to CD (i.e. code 'COLLAB') and DfS (i.e. code 'SUSTAIN') were identified in the publications dataset by searching for the keywords

employed in the Scopus search; the relevant information was coded into six predetermined categories (Table 2) using a hybrid coding approach (Saldaña 2013) to make insights on processes, competencies, motivations and implications related to both CD and DfS emerge.

The second cycle allowed the extraction of rich quotes from the dataset. The team conducted a second round of coding using the Complex Coding Query feature on MAXQDA: through this feature, it was possible to retrieve the whole text segment where two of the different categories identified in the first cycle were overlapping (Figure 1).

The feature helped refine the coding and understand the relations between each category of codes related to CD and those related to DfS (Table 3). This second coding cycle resulted in 141 coded quotes. At an interpretative level, these excerpts

Table 2. Predetermined codes used in the first coding cycle, descriptions and count of coded segments.

Category	Description	Coded segments
SUSTAIN & PROCESS	The processes, methods, tools, ways in which sustainability is pursued in the study or design project.	175
SUSTAIN & CAUSE-EFFECT	The reason why (research on) sustainability is needed in design and what will be the effect/impact of (researching on) sustainability on design.	130
SUSTAIN & COMPETENCES	Statements related to competences, skills, knowledge (i.e. needed, developed, lacking) related to sustainability.	58
COLLAB & PROCESS	The processes, methods, tools, ways in which collaboration is pursued in the study or design project.	203
COLLAB & CAUSE-EFFECT	The reason why (research on) collaboration is needed in design and what will be the effect/impact of (researching on) collaboration in design.	101
COLLAB & COMPETENCES	Statements related to competences, skills, knowledge (i.e. needed, developed, lacking) related to collaboration.	66
TOTAL		733

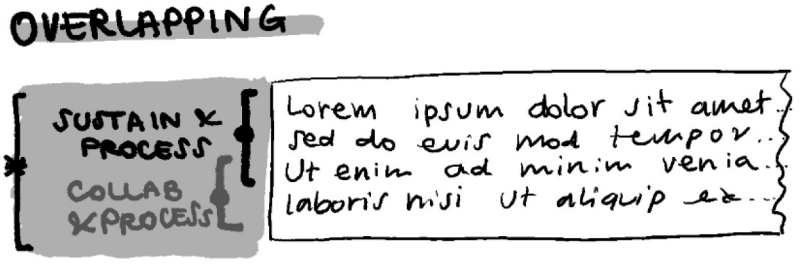

Figure 1. Visual representation of the MAXQDA overlapping feature used.

Table 3. Count for overlapping categories of codes in the second coding cycle, allowing the identification of rich quotes.

		COLLAB &		
AND		PROCESS	CAUSE-EFFECT	COMPETENCES
SUSTAIN &	PROCESS	62 codes	5 codes	8 codes
	CAUSE-EFFECT	11 codes	24 codes	6 codes
	COMPETENCES	5 codes	3 codes	16 codes

('rich quotes') explicitly highlighted connections between CD and DfS and were consequently considered the primary dataset to be analysed in the third analysis cycle. It should be noted that the most prominent overlapping occurs at the intersection of the same categories related to both CD and DfS (see Table 3). In other words, most overlappings – and thus rich quotes – contain information on processes, competencies, motivations and implications related to both collaboration and sustainability in design.

2.5. Collating, summarizing and reporting the result: the activity theory lens

The rich quotes were analysed in the third analysis cycle using activity theory, a theoretical model to describe the mediating process through a seven-component system (Engeström 2000, 2015; Sannino and Engeström 2018; Tessier 2020). AT was selected due to its systemic perspective on complex systems; it can be employed to analyse a single activity or to study, with a broader perspective, an ecosystem or a series of practices, their logic, contradictions or performance. AT has been extensively used to study organisational structures, collaborative dynamics, efficiency, and communicative challenges (Engeström 2008; Rantavuori, Engeström, and Lipponen 2016). This approach allowed us to use AT as a systemic lens to map the complex interrelations shaping design activities related to collaboration and sustainability described in the literature. Employing AT to interpret a spectrum of design practices rather than a single design activity also presents limitations, particularly in capturing context-specific nuances of each practice. These trade-offs were considered in our interpretative process. CD and DfS could be represented as two independent systems of high complexity, which could be as urgent as exploring the overlapping of both; such representations are beyond the scope of this study.

Moreover, AT is based on a visual model (Figure 2) that facilitates the definition of fundamental components of social systems and their interactions (i.e. subject, object, tools, rules, community, division of labour and outcome) and sheds light on the interrelations and contradictions between these components. Consequently,

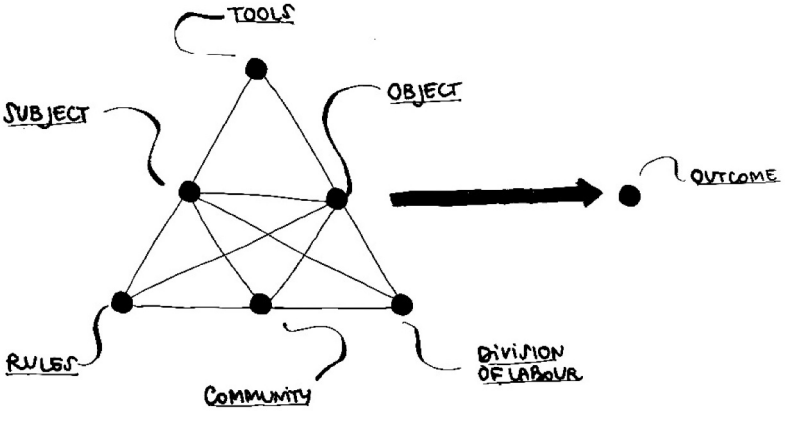

Figure 2. Activity theory system.

Table 4. Quotes distribution across the AT system components and their definitions.

AT component	Associated citations	AT definition
Subject	14 quotes from 11 publications	The subject is an individual or a team central to the studied activity.
Object	5 quotes from 5 publications	The object is the aim of the activity towards which actions are oriented. It is often considered the problem-solution space.
Tools	23 quotes from 12 publications	The tools are mediating instruments, either cognitive or material, that accompany the development of the system.
Rules	7 quotes from 7 publications	The rules are the existing or emerging regulations, norms, principles, standards or guidelines.
Community	31 quotes from 15 publications	The community comprises the stakeholders who are influenced directly or indirectly by the activity development.
Division of labour	9 quotes from 8 publications	The division of labour is the distribution of work, power, and hierarchy between the components and actors of the activity.
Outcome	11 quotes from 9 publications	The outcome is the motive of the activity and the focus of the system.

choosing AT would enable the team to define the essential components of collaboration and sustainable design initiatives as they emerge from the rich quotes. As part of the third cycle, the rich quotes were associated with one or more AT system components (Table 4) to decode the model's specific components and, ultimately, have a systemic overview of the interactions between CD and DfS systems. Table 4 shares short definitions of each component based on Zahedi and Tessier (2018), who worked to build a designerly AT framework. The definitions facilitated the analysis process by allowing the identification of relevant thematic keywords, highlighting recurring subjects and drafting a comprehensive definition of each component concerning collaboration and sustainable design. Thus, we aim to have a finer understanding of the practical implications of the system's components. These interpretations are shared in the next section and are positioned as part of a complex activity system.

3. Results: activity system component descriptions

The subject component refers to the individual designer or the design team involved in the activity, that is, here, a design project involving both CD and DfS. In other words, we identified the emerging themes by interpreting rich quotes. Various roles are attributed to designers (subjects): some are widely acknowledged, such as creative thinkers and innovators. These roles are shared here under the subject component rather than the division of labour, as they primarily reflect designers' identity, agency, and social positioning in the system rather than explicit task distribution. Other roles are more rarely associated with designers: disseminators of ideas and incubators, facilitators, provocateurs, social organisers, mentors, fixers (White and van Koten 2016), creators of dialogues (Palmieri, Huybrechts, and Devisch 2021), and leaders (Nunes 2017b). These emerging roles underline the pivotal influence of designers in social contexts when dealing with sustainable values: designers can influence, support, and guide while generating discussions, stimulating debates, or questioning the status quo. Nunes states that 'designers need to create conditions that stimulate the ability of individuals to

compose the systems, experimenting original ways of being and of acting in collaborative paths' (2017b, S1015). Therefore, when studying the subject-designer, the designer has a guiding role in influencing the system and its future developments.

Besides roles, designers were associated with a set of fundamental social attitudes for the activity system, for instance, social learning, knowledge exchange self-awareness and self-responsibility (Calvo and De Rosa 2017), , participation, empathy (White and van Koten 2016), , ethics, trustworthiness (Melles, de Vere, and Misic 2011), eco and social responsibility (Dominici 2017). According to the research team's interpretation, the overall self-reflective attitude while creating bridges to connect with others emerges as central to expanding the sustainable system. These attitudes offer greater consideration towards others' strengths, perspectives, and knowledge and emphasise the need for reflectivity. The attitude and vision of the subject-designer are a primary influence on the activity system as the subject-designer is at the front of its development. However, the contribution of communities and others (e.g. users, stakeholders, manufacturers) is crucial to work towards sustainable solutions.

Lastly, the analysis revealed certain barriers associated with designers, potentially limiting the activity system's development. For example, uncertainty in the process or the relationship with others (Charnley, Lemon, and Evans 2011), western neoliberal structures and a need for change in predominant values (Kendall and Dearden 2020), and the time and resources available (Palomo-Lovinski 2015). While some of these barriers might seem shared in all design projects, the economic and political context might heavily influence the development of sustainable design initiatives, and this aspect is closely tied to the subjects, their actions, processes and mindsets.

> A crucial realization here, however, is that we as researchers and co-designers are agents for unsustainable patterns of existence. We are commonly enmeshed [. . .] in a system that draws on Western neoliberal structures. [. . .] embedded in our values and our ways of working. Seeking a codesign practice that is sustainable thus requires [. . .] participation and inclusion of other values, but also structural changes to our projects and our ways of working. (Kendall and Dearden 2020, 92)

The object is the problem-solution space that justifies the design process, being its aim and motivation (Table 4). The rich quotes analysis revealed little information about the object component from a systemic perspective. The content of the quotes was often specific to the project or context (e.g. project types, disciplinary areas), making generalisation difficult. The analysis indicates that the definition of objects in sustainable design has become increasingly multifaceted, requiring a systems-thinking approach to integrate different dimensions (i.e. environmental, social, economic). From a design for sustainability perspective, the problem space is framed considering climate change, environmental impact, and sustainability (Mainsah, Morrison, and Edeholt 2017). Solutions should address these elements through reflective thoughts or encouraging adaptive and regenerative systems (Mainsah, Morrison, and Edeholt 2017). Significant challenges arise in defining design objects, as sustainability-driven projects are multifaceted, highly complex, and often fuzzy or messy (Hyysalo et al. 2019). Overall, there seems to be a lack of outstanding project examples to inspire further initiatives (Hyysalo et al. 2019), and a dilemma about whether to show or 'hide sustainability in aesthetically pleasing attributes' (Palomo-Lovinski 2015, 23).

The tools component describes the cognitive and material instruments mediating the design process. Although papers shared various approaches to conducting sustainable design projects, no specific methods or strategies were identified to stimulate collaborative and sustainable initiatives. This observation is contextual to the dataset, hence a research limitation. While the literature might share numerous codesign methods for sustainability, the analysis revealed a gap in frameworks integrating collaborative processes and systemic sustainability principles.

> [. . .] is often uncertain how actors from different organizations are to integrate successfully and furthermore the holistic process that they should follow, in order to reach a more sustainable solution, is currently unclear. (Charnley, Lemon, and Evans 2011, 158)

Although some papers were explicitly oriented towards design training, no tendencies could be identified for training recommendations; some isolated recommendations were identified. For example, Dominici (2017, S1454) identifies six overarching guidelines: critical thinking, eco-literacy, collaboration, active role, aware leadership, and divergent thinking. Others also mention the need to 'build a network of design schools centred on knowledge exchange and design strategies for climate futures' (Mainsah, Morrison, and Edeholt 2017, S103) or 'an elective class [. . .] that emphasise collaboration of an interdisciplinary approach focusing on a sustainable product' (Palomo-Lovinski 2015, 19). The rest of the rich quotes associated with the AT system's tools component primarily focused on the skills needed for collaborative and sustainable projects. In addition to the more commonly mentioned design skills (e.g. creativity, innovation, dealing with uncertainty), transdisciplinarity is particularly crucial for DfS activities. Other predominant skills emerge regarding the sensibility towards others, i.e. learning with and from others, working with others, considering other perspectives, disciplines or expertise, and collaborating. Systems thinking stood out from the analysis as a fundamental cognitive approach when acknowledging the complexity of new challenges. On that matter, Charnley et al. mentioned that 'literature in the areas of collaborative, sustainable and system level approaches to design increasingly identifies techniques such as systems thinking' (2011, 156), while Baek and Bhamra advise:

> [. . .] that a systemic approach supports design for sustainability with methodologies that stimulate collaboration among stakeholders sharing a problem. As collaboration extends across the value chain [. . .] sustainable design researchers and practitioners increasingly need to manage the complexity associated with dilemmas and tensions arising from collaborations. (Baek and Bhamra 2022, 363)

The rules component is associated with existing or emerging constraints, regulations, standards or guidelines (e.g. ISO standards, sustainable product regulations). Regarding the activity system, the rules are primarily framed on the sustainable development pillars, 'economic growth, environment stewardship and social progress' (Nunes 2017b, S1015). In brief, the economic pillar refers to profitability, viability, and fair distribution of wealth. The environmental pillar in the reviewed studies primarily emphasises reducing ecological footprints and preserving ecosystems, though a broader shift towards regenerative approaches is emerging in most contemporary conceptions (Fry 2009). The social dimension of sustainability considers

human health, social equality, and environmental justice. These pillars represent the paradigm adopted, guiding decision-making and complementing more context-specific rules or values. These simultaneous considerations are combined with other concerns, such as the less widely known *human* pillar in sustainable development, which values life quality and conditions, or the sociocultural influences that ensure attention is given to the context-specific, historical or cultural aspects. These can function as opportunities for innovation and adaptations by 'catalys[ing] transition' or encouraging durable processes and solutions (Wallace 2022, 1019).

The community component comprises the stakeholders actively involved in or affected by the activity, as associated with the majority of rich quotes, which underline the central position of other social actors in the transition design process. The first theme that emerges from the analysis is the importance of collaborating with a diverse set of actors by establishing partnerships with policymakers shaping regulatory frameworks, private entities for their technological expertise, public institutions and local communities for their experiential knowledge, and research experts or academics with theoretical knowledge and methodological rigour (Charnley, Lemon, and Evans 2011; Leal et al. 2022; Mainsah, Morrison, and Edeholt 2017; Nunes 2017a, 2017b). These partnerships include 'actors from a variety of different backgrounds, disciplines and sectors to develop an innovative, sustainable, and optimised solution at a whole system level' (Charnley, Lemon, and Evans 2011, 156). Additionally, stakeholders (i.e. experts and non-experts) are invited to participate in the design process, allowing a multi-perspective approach and underlining the social dimension of DfS. Another emerging theme is the importance of including stakeholders to favour participation, co-development, listening, and interaction with future users, consumers, and producers (Charnley, Lemon, and Evans 2011). Participation also encourages the stakeholders' responsibility (Melles, de Vere, and Misic 2011), a 'holistic view of the system' (Charnley, Lemon, and Evans 2011, 172), 'the transformation of stakeholders' (Yang and Sung 2016, 34), individual accountability, 'social learning [. . .] and collective action' (Calvo and De Rosa 2017, S1720). Lastly, social learning resulting from creating partnerships and including stakeholders in the process emerges as a central theme around the community component. As a bottom-up approach, social learning emphasises the importance of including others when working for the transition, ensuring solutions are adapted to context, and using social interactions as a lever in creative communities to stimulate innovation (White and van Koten 2016).

The division of labour component explains how work is distributed as part of this process through hierarchy, design approach and collaboration. In agreement with the previous description of the community component, stakeholders' inclusion demands a strategic division of roles within the activity, where subjects can take different roles, from facilitators coordinating the communities' efforts to interdisciplinary experts with technical knowledge. The analysis revealed that collaboration is central, and clear responsibilities promote the efficiency and strength of the design project. Instead of placing the designer as the leader of design projects, more equalitarian relations are promoted so that all points of view are equally considered. Codesign and systemic perspectives are frequently mentioned approaches to encourage group work, participation, and inclusion of others (Baek and Bhamra 2022; Kendall and Dearden 2020), but also multidimensional, interdisciplinary, transdisciplinary and transcontextual understandings (Melles, de Vere, and Misic 2011; Nunes 2017b; Wallace 2022). Collaboration,

stands out as the privileged work approach that favours the significant inclusion of communities in the process. As mentioned previously, including and considering others is crucial to motivate social change, and 'collaborative relationships' (Baek et al. 2018, 73) seem to ensure more equalitarian relations between subjects (i.e. designers), stakeholders and partners. Wallace states that:

> However, deeper communication and collaboration within multi-disciplinary teams will also be required to meet the complexity in these transitions, with a particular sensitivity to the ways transitions are shaped by their cultural context. (Wallace 2022, 1019)

Finally, the outcome component, which represents the motive of the activity and the focus of the system, stresses the finality of the design process and contributions to a transformative process (Sangiorgi 2011) or systemic change (Charnley, Lemon, and Evans 2011), which is needed to face 21st-century challenges. Among others, two characteristics of this transformation emerge as the most relevant: the transformation of people and the transformation of the designed object. The words of Leal et al. (2022), while describing the approach adopted in their research, well exemplify these two primary outcomes when collaboration is put forward:

> This approach comprises two strands: one that intends to empower the trainees (or non-professionals that might use this approach in the future) by producing new knowledge and valuing autonomy through a model of designing new sustainable products and another that values codesign through a model of collaboration among the trainees (or different communities in need) and master's students (designers), in which both groups work together to produce and improve previously designed products. (Leal et al. 2022, 56)

In sum, CD is adopted as an inclusive work approach in design projects to empower designers (i.e. subjects) to achieve two transformative outcomes: capacity building of community and stakeholders and an improved designed product (i.e. object). Even if some authors present these two jointly (e.g. Charnley, Lemon, and Evans 2011; Leal et al. 2022), many others point to one or the other as the significant sustainable outcome when collaboration is employed in the design activity. On the one hand, several authors present people's change as the most crucial sustainable outcome when CD is employed as a tool.

Some argue that collaboration between designers and stakeholders promotes the transformation of the latter (Yang and Sung 2016) towards reinforced social cohesion (Baek et al. 2018), collective reflection (Calvo and De Rosa 2017; Sangiorgi 2011) and the adoption of more sustainable practices or solutions (Nunes 2017b). On the other hand, the change in the designed objects is pointed out by some other authors as the primary outcome of the activity. More specifically, Dominici (2017) argues that collaboration with experts from other domains is needed to change designers' practices towards more socially and ecologically responsible ones; collaboration with people is, according to the author, a relevant tool for educating designers on systemic design. In conclusion, the first key result is that collaboration is instrumental in developing more sustainable outcomes, thus providing the team with crucial insights into the causal nexus emerging between CD and DfS. According to all the findings, the resulting visualisation of the Collaborative Design for Sustainability AT system (see Figure 3) was developed to show the relationship between components.

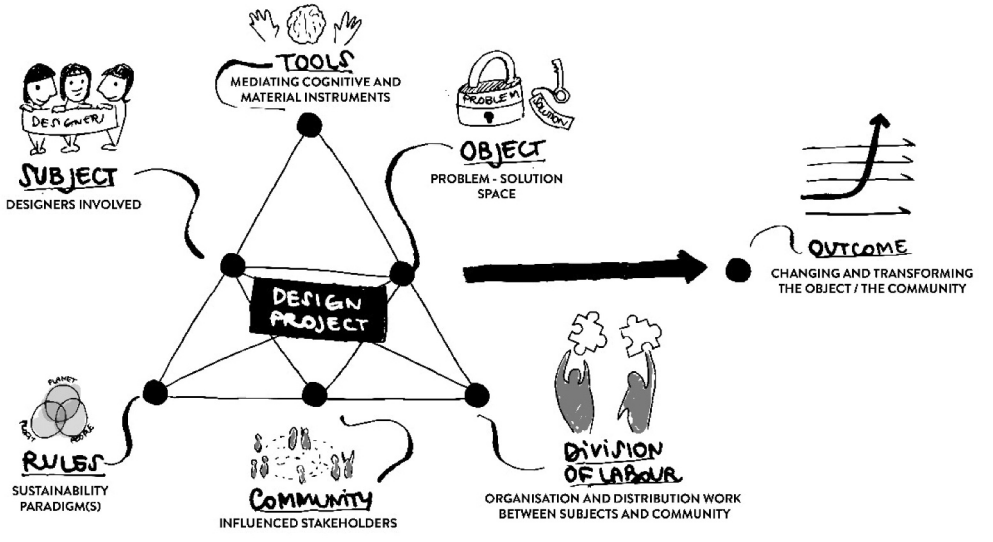

Figure 3. Collaborative design for sustainability activity system.

4. Activity system analysis through statement cards: three emerging tensions

Another method was adopted to build an additional interpretative layer to identify the emerging tensions from the first analysis. AT's tensions (or contradictions) are positive development drivers (Engeström 2000, 2001). They create opportunities for innovation, change, and improvement. Tensions also translate a system's complexity by acknowledging mediation between its components and defining their interactions. As tensions grow, they stimulate opportunities to 'reconceptualize [and] to embrace a radically wider horizon of possibilities than in the previous mode of the activity' (Engeström 2001, 137). In this sense, the tensions presented in this section are primarily predominant interactions identified through our analysis process but present high potential for sustainable development of activity systems when considering CD and DfS as an integrated vision. The AT elements and their interrelations were integrated with statement card analysis (Sanders and Stappers 2012; Stappers 2012), a qualitative technique to collaboratively move across different interpretative levels (Table 5), such as moving from data to knowledge (Ackoff 1999).

While AT guided the organisation of the system under study, the statement cards helped clarify the components' interactions, contributing to the sense-making process

Table 5. Different interpretative levels (adapted from Stappers 2012).

Level	Example	Explanation
WISDOM	Decisions to use a theory or not	How to make use of the other layers
KNOWLEDGE	Theories, categories, patterns	Abstracted, generalized relations between information
INFORMATION	Paraphrases, codes	Symbolic code of interpretations
DATA	Photos, videos, transcripts	Selected pieces of evidence from the field research
PHENOMENON		That what happens in the world

and the identification of challenges. Statement cards visually support the data (i.e. rich quotes) and information (i.e. researchers' interpretation) connection: cards are physically placed into the space to organise the information into knowledge. In the present research, they have been used to analyse further the rich quotes obtained with the third coding cycle.

To this extent, the rich quotes have been used as data and associated with one paraphrase of the interpretation assigned to that excerpt (i.e. information level). Such interpretation has been built by using elements of AT in caps lock to make them more visible (see Figure 4). All the statement cards were imported on a shared online board and organised according to emerging patterns; some recurrent interrelations became evident. Consequently, statement cards were clustered and associated with findings noted on virtual post-its (Figure 5). By structuring the shift from *data* to *knowledge*, we constructed a coherent discourse that bridges diverse Collaborative Design for Sustainability (CDfS) activities. This systemic interpretation highlights tensions between elements previously studied in isolation, offering a new integrative framework for understanding the dynamics of CDfS activities.

4.1. The outcome of the design project is changing the COMMUNITY or the OBJECT

The first tension seeks to clarify the outcome component of the system (Figure 6). As previously noted, the outcome relates to seeking constructive and regenerative impact of environmental and social aspects of the design. To a certain extent, this finding shows that CD is relevant for designers to transform the community involved or the designed object into a more sustainable one.

The analysis of this first tension reveals that these are the two primary transformative outcomes that originate from the system. The two outcomes are interrelated, given the connection between the object and the community involved in the project when a collaborative process is in place. However, suppose one considers these two outcomes alternatives (i.e. using the OR word in the phrasing). In that case, one is forced to look at the system by choosing the priority of

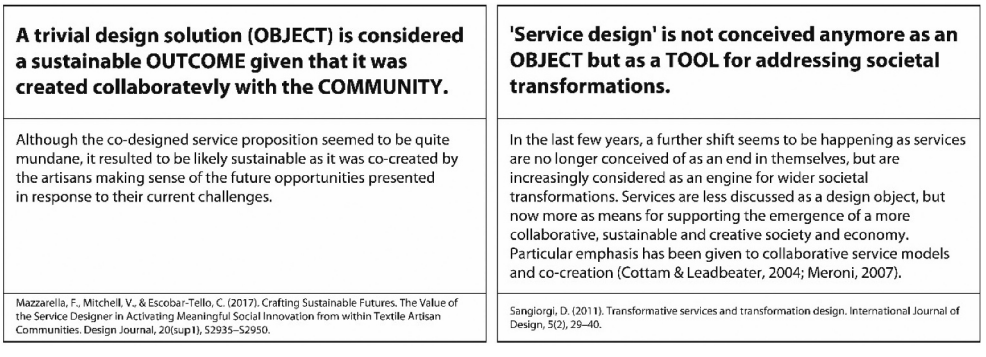

Figure 4. Examples of two statement cards: the upper part contains the interpretation, and the lower the rich quotes retrieved from Mazzarella, Mitchell, and Escobar-Tello (2017) and Sangiorgi (2011).

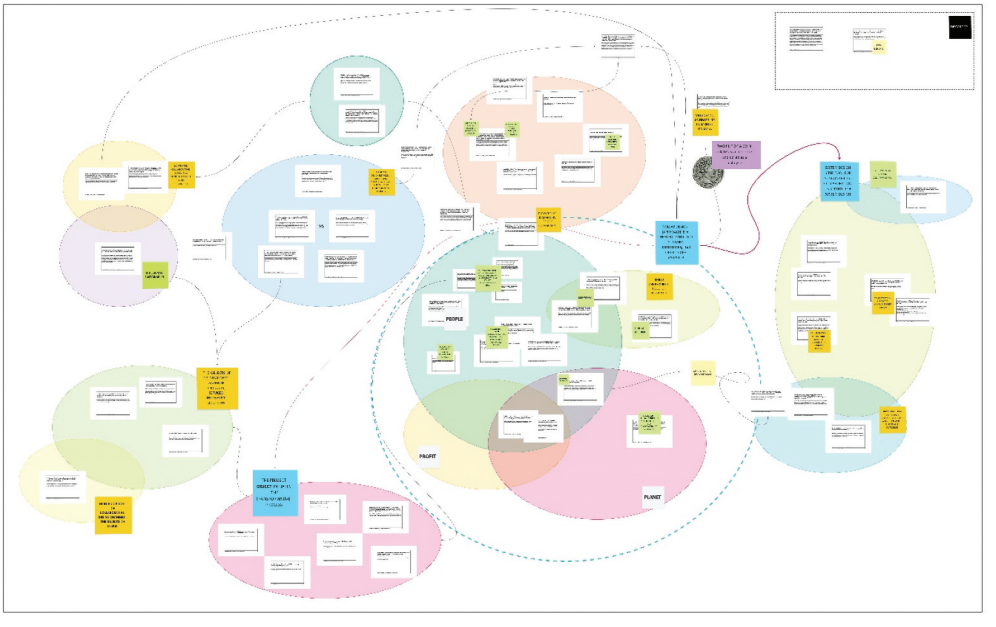

Figure 5. Research team's shared online board for the statement cards analysis.

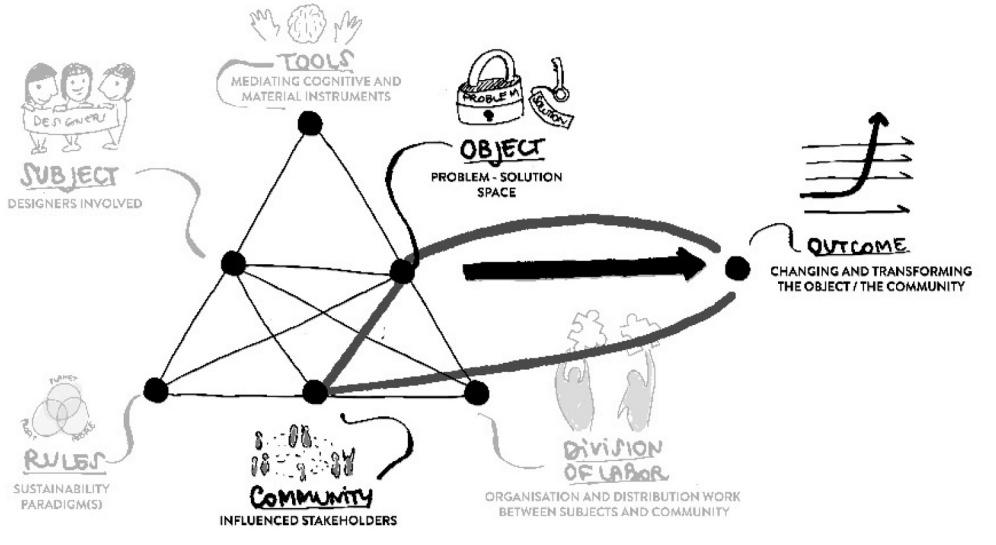

Figure 6. The first tension's visualisation between OBJECT, COMMUNITY, and OUTCOME.

the activity in terms of outcome (Table 6). Acknowledging these considerations is helpful when planning a design activity with a transformative goal that implies collaboration, as it clarifies the expected outcome of the (collaborative) design activities, which influences the other components of the activity system and encourages shared understanding.

Table 6. Building the collaborative design for sustainability framework: first tension.

Intented OUTCOME is…	OBJECT-COMMUNITY interaction
… changing the COMMUNITY	DESIGNING AN OBJECT TO CHANGE A COMMUNITY Object construction as the means for stakeholders' changing process
… changing the design OBJECT	A COMMUNITY TO CHANGE THE DESIGN OBJECT The stakeholders' perspectives serve as a means for the object-changing process

4.2. The role of the subject in the DIVISION of LABOUR depends on the OUTCOME

The second tension focuses on the designers' role (s) in this multipurpose process (Figure 7). The designers' role(s) are often addressed, and the competencies designers bring (compared to other experts), intended here as practical and cognitive tools, are often quite generically listed in the surveyed literature. The results showed that designers' more crucial attitudes to the CD project are mostly social: first, the ability to connect with others by employing their empathy and, second, bridging between different perspectives towards a shared vision. Then, these attitudes can be valued to reach the outcome by:

(a) facilitating perspective-taking and mutual understanding between different stakeholders involved through object framing.
(b) creating an object with improved transformative impact by synthesising different stakeholders' perspectives.

The second tension is influenced by the expected outcome of the overall activity system and influences the designer's primary role in the process–i.e. facilitator or creator. This will guide the designer's vision, actions, and decisions throughout the process.

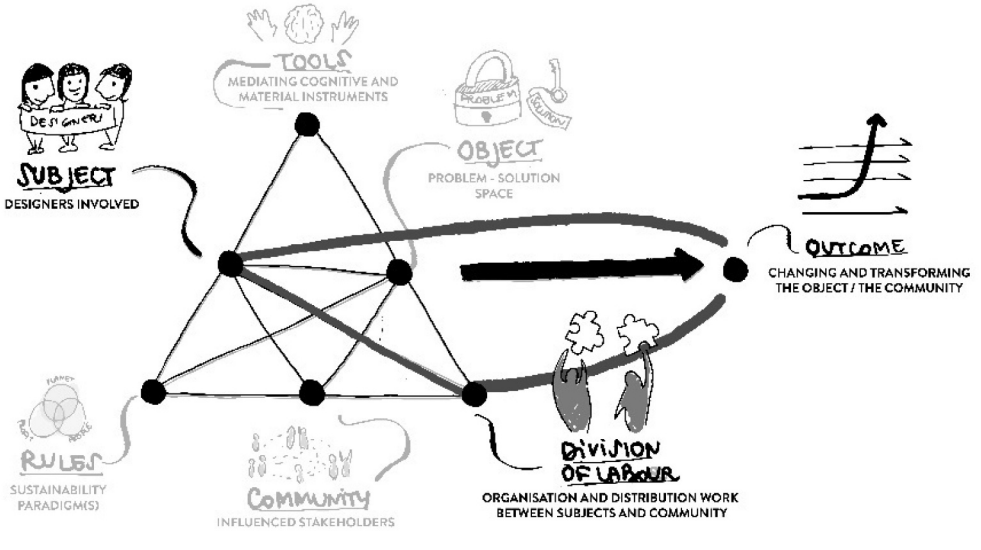

Figure 7. The second tension's visualisation between SUBJECT, DIVISION of labor, and OUTCOME.

Table 7. Building the collaborative design for sustainability framework: second tension.

Intented OUTCOME is...	OBJECT-COMMUNITY interaction	SUBJECT-DIVISION OF LABOUR
... changing the COMMUNITY	DESIGNING AN OBJECT TO CHANGE A COMMUNITY Object construction as the means for stakeholders' changing process	DESIGNER(S) AS THE FACILITATOR(S) Uses the object creation to foster mutual and shared understanding with others
... changing the design OBJECT	A COMMUNITY TO CHANGE THE DESIGN OBJECT The stakeholders' perspectives serve as a means for the object-changing process	DESIGNER(S) AS THE CREATOR(S) Understands others' perspectives and includes them accordingly

The assumption that the division of labour is highly non-hierarchical is interpreted as both an asset and a contradiction, as surfaced in the literature analysis and then presented in the results section: how can designers be the leaders of the process and be in the same power position as non-designers in the design process? Designers have a guiding role in the design process, and this role also depends on the intended outcomes. Designers do not necessarily hold a privileged position in the transformation process since the object of the design project can be a tool for the broader transformation process. However, when an artefact is designed, be it a product, a service, a strategy, a policy or any other type of *human-made object*, designers have competences related to understanding people, how the object is constructed and the human-object interactions in context. Like the first tension, this finding could also help reflect on and help plan the designer's role in CD settings with transformative aims (Table 7).

4.3. The OUTCOME requires systemic thinking as a TOOL and sustainability paradigm as a RULE

The last tension concerns the components of the tools and rules (Figure 8). These two components are considered the fundamental mindset to support the designer's process in the activity system, aiming for transformative and sustainable outcomes. Whether the outcome is about changing the community or the design object, both perspectives should be tackled from the beginning of the process. Although not directly connected – with the subject as the linking component–, the tools and rules are complementary and seem to influence one another intensely.

A predominant finding from our analysis is that systemic thinking (tool) and sustainability paradigms (rules) are employed in projects with transformative aims. Hence, based on the interpretation, they are both fundamental to the subjects from the beginning of the project to mediate the whole activity and should be considered simultaneously (Table 8). Also, the influence of collaboration is significant in fully engaging with these components, as it will nurture the systemic considerations of the subject(s) guiding the project by supporting the outcome's transformative process. Moreover, several authors present the collaborative approach as necessary to foster systemic thinking and a systemic view. Exploring systemic design literature further in future research could clarify its relationship with design and collaboration. This finding is especially significant for design education to ensure that future

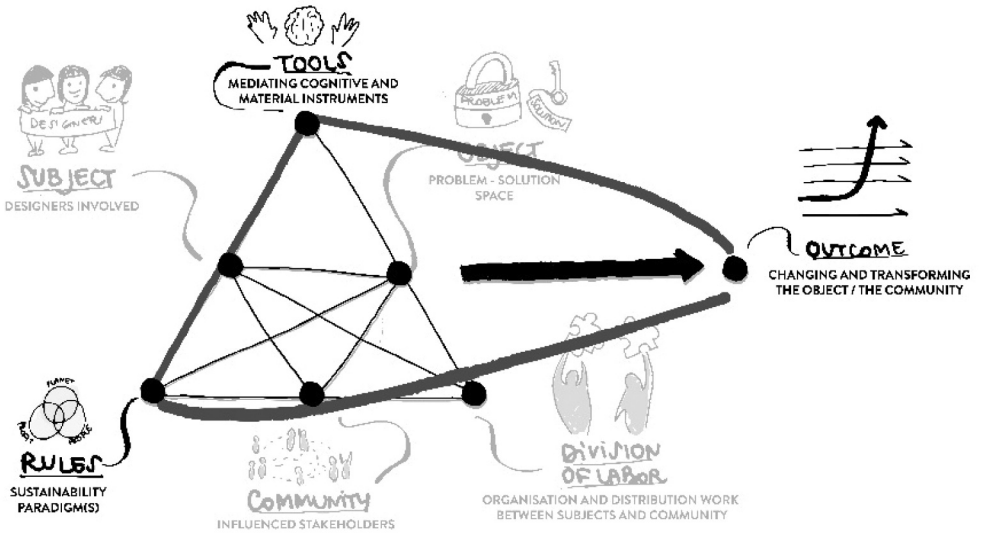

Figure 8. Third tension's visualisation between OUTCOME, TOOLS, and RULES.

Table 8. Collaborative design for sustainability framework with all three tensions integrated.

Intented OUTCOME is...	OBJECT-COMMUNITY interaction	SUBJECT-DIVISION OF LABOUR	TOOLS-RULES
... changing the COMMUNITY	DESIGNING AN OBJECT TO CHANGE A COMMUNITY Object construction as the means for stakeholders' changing process	DESIGNER(S) AS THE FACILITATOR(S) Uses the object creation to foster mutual and shared understanding with others	FUNDAMENTALS Systemic thinking is the required cognitive TOOL and the sustainability paradigm informs the RULES
... changing the design OBJECT	A COMMUNITY TO CHANGE THE DESIGN OBJECT The stakeholders' perspectives serve as a means for the object-changing process	DESIGNER(S) AS THE CREATOR(S) Understands others' perspectives and includes them accordingly	

designers are well-equipped with the tools and mindsets most recommended for a sustainable transition.

5. Discussion

The analysis process of the literature gathered through the scoping process guided us towards identifying underlying tensions and interactions related to CD initiatives aimed at DfS, often hidden in such multifaceted phenomena. The study develops a cohesive discourse for diverse elements, often studied in isolation. The reflections shared in the paper clarified these dynamics and complex interrelations. The Collaborative Design for Sustainability activity system (Figure 3) and framework (Table 8) represent two significant research achievements, as the two results help define an explicit approach to managing CD initiatives focused on sustainability. The framework emerges from a first exploration of the question and will need to be

developed further based on empirical experimentations with designers in practice. By synthesising AT's theoretical insights with our analysis, the findings could support and facilitate the operationalisation of these initiatives, guiding practitioners effectively. The framework can help define the scope of a design project by clarifying its main objective (i.e. object or community), the roles of the designer (i.e. facilitator or creator), and the essential tools to operate during the process. These elements could contribute to a shared understanding within design teams, which supports more performative design solutions and collaborative processes (Kleinsmann 2006).

The research helped develop insights into the relationship between CD and DfS, emphasising that collaborative design for sustainability is closely related to systemic thinking. Here, it is acknowledged that the developed activity system and framework aim to understand and facilitate collaboration in DfS processes, which are only tools within a much larger transformation process (and system). While design could be relevant, it is only one part of a broader journey towards a sustainable transition. The findings emphasise the importance of systemic thinking and the sustainability paradigm adopted. These will likely play a more critical role in the transformation process than collaboration alone. The study highlights the necessity of including collaboration as an essential component of systems that foster systemic thinking, whether the primary intended outcome is community change or object transformation. However, collaboration is often mentioned without clearly articulating the specific methods, techniques, or rules that make it effective. This lack of clarity can hinder the success of collaborative efforts, particularly in complex, multi-stakeholder environments like those encountered in DfS initiatives. This result indicates the need for more explicit frameworks and guidelines to structure and enhance collaborative practices, ensuring they contribute effectively to systemic change. Another contribution of the study is to explore design literature through a novel methodological approach at the intersection of sustainability, collaboration and design. Specifically, AT and statement card analysis were employed to navigate the complexity of these issues. This methodology allowed the authors to delve into uncharted territory, providing a structured way to analyse and understand the dynamics of CD initiatives aimed at DfS.

Despite its valuable insights, the study faced several limitations. Firstly, the lack of clear information on training, methods, approaches, and strategies for enhancing collaboration in practice. This gap in the retrieved literature made it challenging to develop a comprehensive understanding of effectively operationalising collaboration within the system. Moreover, the data included in our study were limited to publications from 2009 to 2023, with a substantial increase since 2020. As the overall conception of sustainability has consistently evolved throughout the timespan, the dataset is limited as it includes sources reflecting a reductionist perspective. We did not limit our selection to publications sharing a particular definition of the concepts (i.e. DfS and CD) in the belief that this contributes to the study's richness by mixing multiple viewpoints and visions. The literature collection was considered, while informative, as a means to explore the field and foster ongoing conversations between the authors over a year and a half rather than as a definitive data source. A significant increase in publications on the topic during the study development was recorded, underscoring the growing interest in this area. The study was conducted in a rapidly

evolving field, potentially affecting the relevance and applicability of some findings. Future research should focus on applying the outputs of this study in practical settings to test their effectiveness. There is also a need to explore how CD can motivate more sustainable initiatives in educational contexts and professional practice. Additionally, future studies should investigate how to prepare designers to be effective and sensitive facilitators or creators in collaborative processes, addressing the gap identified in our study regarding the lack of more precise methods and training for enhancing collaboration. This research offers initial insights into how to equip designers better to navigate the complex dynamics of collaborative design for sustainability.

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