Original Research

Touching on "Collective Collaboration Mapping": How Can Co-Creation Contribute to the Process of Equal Collaboration for an Inclusive Citizen Science Approach?

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Abstract: Citizen science as an approach for equal collaboration between people with different backgrounds and knowledge needs to go beyond a contributory approach in ways that are more deliberative and accessible. This paper proposes a "collective collaboration mapping" framework based on touchpoints and co-creation methods to collectively create pathways for collaboration using intermediate-level knowledge. Intermediate-level knowledge relates to the uncertainties, imbalances, and alternative strategies that are disclosed while the design or research process unfolds itself. Such moments provide an opportunity for collective reflection and decision-making through the recursive character of the design process. The recursive character of the design process refers to the initial step of people coming together to work on an issue for positive change. "Collective collaboration mapping" (CCM) effectuates the recursive character within the design of the research process by operating as a reflective extension for creating an equal and inclusive citizen science approach. The CCM framework will be presented as a dialogue tool to support flexible onboarding, equal collaboration, and synergy of knowledge. The value of this theoretical and conceptual study is to move beyond "being involved" toward "knowledge commons," in other words collective knowledge production.

Introduction

Design as an approach for innovation development has acquired recognition in recent years when addressing societal challenges. This recognition is largely due to the emphasis on active participation (Dorst 2015) with stakeholders and/or end-users in various phases of the design or research process, commonly known as participatory action research (PAR) (Björgvinsson, Ehn, and Hillgren 2012) or human-centered design (HCD). Active participation can be applied on the one hand to support design decisions by including people's needs, values, motives, ideas, creativity, and goals for design purposes based on isolated design questions called research-oriented design. On the other hand, in the case when research is driven by design within a larger research process that contributes to knowledge generation, known as design-oriented research (Fallman 2007). This article explores this multifaceted nature of the

design process, distinguishing it as the process of creating a product or service, design as research for the production of new knowledge, and as a systematic approach to shaping the research process itself. Although these practices often intertwine and are interpreted differently in various domains and discourses, it is important to clarify them to avoid any misinterpretation.

Collaborative methods such as co-design, co-creation, and co-production promote creativity, inclusivity, and shared responsibility, resulting in more effective and human-centric outcome (Maase and Dorst 2007; Sanders and Stapper 2008; Vargas et al. 2022). Although co-design, co-creation, and co-production tackle problem-solving, advance product development, and optimize service delivery (Voorberg, Bekkers, and Tummers 2015), co-production primarily engages consumer participation at the latter stages of development. This kind of engagement stands in contrast with co-design and co-creation as they actively involve stakeholders throughout all phases of the design or research process (Prakash et al. 2013; Voorberg, Bekkers, and Tummers 2015). Although co-design and co-creation support active engagement, they have a different approach and purpose. The approach of co-design concentrates on actively involving stakeholders in design activities such as brainstorming, sketching, categorizing, measuring, and testing to collaboratively define and assess requirements for potential solutions. In contrast, co-creation extends its scope to encompass the entire research process of design or scientific research. Here, stakeholders actively contribute to shaping the research plan (Maase and Dorst 2007; Sanders and Stapper 2008; Vargas et al. 2022). Co-creation in contrast, involves the entire research process of design or scientific inquiry, where stakeholders play an active role in shaping the research plan (Maase and Dorst 2007; Sanders and Stapper 2008; Vargas et al. 2022).

Co-creation is the basis for the development of collective intelligence of a group of people, rather than being dependent on the isolated expertise of specialists. This approach supports a group to navigate through uncertain terrain during the design or research process, by embracing a repetitive cycle of internal knowledge exchange, collective decisions making, and engaging in experimentation (Rill and Hämäläinen 2018). Co-creation not only supports the validation of design and research decisions through collective decision-making, but it also helps to ease the conversation between designers, researchers, and stakeholders (Senabre Hidalgo et al. 2021). Moreover, in a collaborative setting, communication is key to ensure that everyone is comfortable to discuss an issue in detail, whether a problem or opportunity, and make sure that an agreement on the steps to collaboratively create positive change is open and transparent (Senabre Hidalgo et al. 2021).

Following a collective decision-making process, people can make decisions on a systematic approach of finding research questions and formulating research activities by determining the most effective methods when engaging in a collaborative initiative. In this way, working together based on the co-creation process can support people to capitalize on each person's knowledge, experience, and skillsets to set and achieve a common goal. Hence,

co-creation has the potential for new ways of involvement in design and research activities to work together with the public as equal partners through the acceptance of the value of different expertise and knowledge on a long-term basis, either prior to, during, and after the design or research process (Björgvinsson, Ehn, and Hillgren 2012).

The Role of Co-creation in Citizen Science Collaboration

While the term citizen science has many definitions, diverse participation levels, and categorized frameworks (Arnstein 1969; Irwin 2015), citizen science can be broadly summarized by the description presented by Hecker et al. (2018), who state that citizen science is an inclusive approach to involve citizens, or non-trained researchers, in scientific activities spanning all phases of the design or research process. In the context of understanding the interplay between science and society, Irwin (2015) explored citizen science from the point of view of citizens and what they consider to be relevant in new developments affecting their lives. Within his investigation, numerous issues identified by citizens in science shops exhibited a transdisciplinary character, transcending the compartmentalization of scientific disciplines (Irwin 2015; Senabre Hidalgo et al. 2021). Another insight derived from Irwin's research is that contextualized lay knowledge can become an integral component of scientific knowledge. Within an inclusive citizen science approach, the awareness and recognition of the value of different types of knowledge can be realized by contextualizing knowledge claims, through alignment with the expansion of existing methods and epistemologies. Thereby, the potential for synergy and enrichment of scientific discourse becomes an integral part of citizen science (Irwin 2015).

To create an equal and inclusive approach in citizen science, the exchange of experiences, knowledge, questions, and insights would happen in a way that permits communication about the research plan, data, (re-)formulation of the problem, and outcomes. Accomplishing an understanding of how to work together is essential for the collective assessment and evaluation of knowledge to determine when, how, and if it should be incorporated into the design or research process (Ràfols 2019); hence, making it essential to take into account a variety of questions such as, who will take on which role, who is responsible for or is owner of the data or solutions, how will communication be facilitated, what the impact of the collaboration could be, how you want to work together, what power dynamics are at play, how to learn about each other's languages, and discussing ethical issues (Rasmussen and Cooper 2019). In the process of answering these questions an environment for new perspectives could be created that leads to pre-existing questions, categories of data, and ideas for solutions being opened up for collective decision making for selecting the approach and methods best suited for the design or research activities (Driesche van den and Kerklaan 2022).

Effectively, collaboration in citizen science that is equal and inclusive requires the use of co-creation to enable open dialogue between all people interested in issues arising in society

and working together to innovate in design, technology, and science. To accomplish inclusivity within citizen science, the exchange of experiences, knowledge, questions, and insights must happen in a way that permits communication about data for (re-)formulation of the problem, the research plan, and outcomes. This need for fostering inclusive modes of collaboration finds recognition by transdisciplinary approaches (Bijl-Brouwer van der, Kligyte, and Key 2021). This recognition stems from the objective of inclusive collaboration that wants to create transformative innovations that are characterized by their long-term impact on daily lives. This inclusive collaboration is achieved by fundamentally reshaping, consciously and unconsciously, the relationships, positions, and rules between the involved stakeholders (Bijl-Brouwer van der, Kligyte, and Key 2021). Consequently, it is not solely the design or research methodologies that must align with inclusive and transdisciplinary collaboration, but also the very architecture of the research process itself, which should actively support and co-create this collaborative partnership (Senabre Hidalgo et al. 2021).

The purpose of the proposed conceptual framework outlined in this article is aimed to attempt to bridge the gap between different types of knowledge (e.g., insights, experiences, data, information, expert knowledge, lay knowledge). By doing so, this framework seeks to provide practical guidance for the co- creation of an inclusive collaborative environment to create a knowledge platform. This platform is co-created by all involved in the collaborative initiative to include and assess a diverse array of knowledge types. The motivating factor behind this effort lies in the recognition of the inherent value in harmonizing insights from different perspectives and contributions of experts and non-experts, thereby fostering an equal and inclusive approach for evaluation of knowledge and generation of new knowledge through co-creation. (Senabre Hidalgo et al. 2021)

Mapping of Intermediate-Level Knowledge

Collective Collaboration Mapping (CCM) is based on mapping of intermediate-level knowledge, described by Höök and Lowgren (2012, 23–2) as "knowledge that is more abstracted than particular instances, yet does not aspire to the generality of a theory," that is, knowledge emerging from design or research activities to directly inform and shape new designs (Höök and Lowgren 2012; Boon et al. 2021). Intermediate-level knowledge in co-creation of collaboration would relate to the uncertainties, imbalances, and alternative strategies that are disclosed while the design or research process unfolds itself. In other words, intermediate-level knowledge would function as the 'middleman' between design or research activities and the meta level of the collaboration process. Mapping of intermediate-level knowledge would happen through reflecting, assessing, and making decisions on what happens during design or research activities related to the collaboration process. Insights collected by the mapping of intermediate-level knowledge would gradually structure, in a design-oriented approach, the guidelines for creating the collaboration.

Some of the uncertainties, imbalances, and alternatives that can arise in the collaboration process for citizen science include the following (Hecker et al. 2018; Irwin 2015; Driesche van den and Kerklaan 2022):

- Motivation: Volunteering to do research while juggling daily life.
- Motivation: Disappointment in the research results.
- Motivation: Participants' and stakeholders' exhaustion.
- Roles/Learning process: Moving from being a support group (i.e., sharing personal situations) into a research group (i.e., creating value for others).
- Roles: Wearing double hats in the roles of facilitator, connector, and/or researcher.
- Communication: Disagreements on the design of the research process.
- Collaboration/Inclusiveness: Creating and maintaining a safe space for all participants in the research group.

By mapping intermediate-level knowledge, participants could reflect on why certain steps were taken and what needs to be done in each stage of collaboration, resulting in a built-in co-creation of collaboration before, during, and after the design or research is conducted. Moments of intermediate-level knowledge arising would provide an opportunity for collective reflection and decision-making through the recursive character of design that refers to the initial step of people coming together to work together on improving an issue. The integration of mapping intermediate level knowledge would enable an equal and inclusive collaborative process that could not be planned ahead of project time (Björgvinsson, Ehn, and Hillgren 2012).

The Recursive Character of Design

The creative process of design is typically achieved through several iterative loops, each of which leads to optimal options for design decisions that are incorporated into the next step. On a larger scale, this cyclical nature of the design process also plays out "as a whole"(Figure 1) as it refers to the initial step of people coming together to reflectively assess the progress made from that point on. The recursive character of the design process accentuates the opportunity for collective reflection and decision-making about the collaboration process, in a cyclical manner of continually adding to the initial moment of people coming together to create effective and impactful solutions. Hence, the design process is not only iterative, but also recursive in the sense that it is a cyclical form of evaluation. Consequently, this evaluation of the arrangement (i.e., recursively) of the collaboration process touches on the decision of coming together to collaborate, whether this collaboration is working out or not (Biesta 2010).
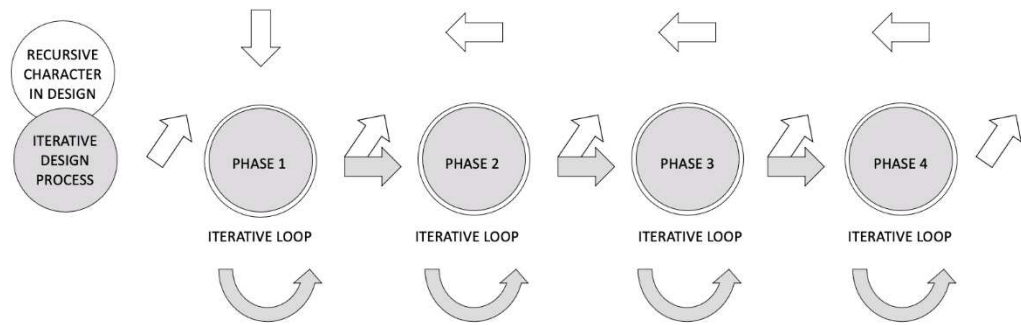
Figure 1: The Design Process Is Not Just Iterative; It Is Also Recursive as It Refers to the Arrangement of the Process Itself

The recursive character of design is reinforced by the fact that intermediate-level knowledge, such as uncertainties, imbalances, alternative strategies, decisions, values, commitment, learning, becomes tangible. Hence, intermediate-level knowledge is generated from the bottom up while conducting research and serves as an informal negotiation model.

In recognizing that knowledge can be sourced from a variety of contexts such as personal experiences, collected insights, theories, and all forms of education, creates value for complex challenges (Vaughn and Jacquez 2020). Nevertheless, the design of the research process becomes complicated when combining different types of knowledge and perspectives. Moreover, as research groups in citizen science can be fluctuating with people entering or leaving and taking on different roles (Vaughn and Jacquez 2020), it is essential to evaluate and monitor the collaboration process. Necessarily, this kind of collaboration would create a need for openness toward different types of knowledge stemming from all corners of society. It is in the assessment of collaboration through the collective evaluation of knowledge lays the potential to create an inclusive and equal platform to establish synergy of knowledge.

Co-creating an Equal and Inclusive Collaboration

This article explores the potential for equal collaboration in citizen science by investigating how synergy of knowledge is generated from collaboration and how to facilitate the collaborative process through co-creation. The first step in the research methodology was to investigate how synergy of knowledge arises from collaboration by taking advantage of emerging intermediate-level knowledge. The second step focused on the recursive character, which refers to the cyclical nature of the design process as a whole to consciously support the co-creation of collaboration, as well as gaining insights from the progression of the collaboration. Subsequently, the third step will identify ways to open the design or research process to include all types of knowledge. In the fourth step the CCM framework was developed aimed at co-creating collaboration in citizen science. This framework includes touchpoints designed to guide the first three steps,

with the potential to create an equal and inclusive knowledge platform to establish synergy of knowledge. In later stages of this study an evaluation of this theoretical and conceptual CCM framework will give a valid interpretation based on experiences of stakeholders involved in collaboration within citizen science.

Openness through "Commons" in Collaborative Design Research

Recent studies have revealed that the practice of collaborative design has evolved, transitioning from transparency and accessibility to new forms of design that involve social partnerships and agreement models (Marttila and Botero 2013). Marttila and Botero have identified four distinct turns in collaborative design: usability, sociability, designability and openness. These turns have significant distinctions within the "co" in co-design, relating to design outcomes, relationships between collaborators, and means and tools used in collaborative initiatives (Marttila and Botero 2013). Marttila and Botero highlight the openness turn, where they introduce the concept of commons as a space for reflective dialogue regarding the capacity of a group of people to come together to shape the design of the design or research process (Marttila and Botero 2013). Hence, Marttila and Botero's identification of the openness turns provides a valuable element in supporting a space for reflective dialogue (i.e., commons) in regard to the collective capacity of the creation of the collaboration process incorporating reflection on intermediate-level knowledge by all people involved.

Lafuente and Estalella, on the other hand, introduce the concept of commons as a way of knowledge production that involves the implementation of "collective, contrastive, and recursive cognitive practices" (2015, 29). Through this process, the concept of commons accomplishes an extent of citizenship by "producing knowledge, community, and commitment" in co-creating the research process and outcomes by including citizens in their design and evaluation (Lafuente and Estalella 2015, 29). Hence, through collective assessment and evaluation of knowledge, an inclusive infrastructure of knowledge emerges that moves beyond collecting and sharing knowledge to the synergy of knowledge, thereby creating a sense of ownership. This inclusive infrastructure of knowledge not only provides a framework for openness in the design of research processes, but it also embeds the inclusion of collaborative practices through co-creation for generating new knowledge.

Creating collaboration would be an ongoing process that is driven by people's knowledge, their interactions with each other, their individual context, and the way they approach things. Through this process, the scope of co-creation expands to include a broader public in all phases of the research process, beginning with problem identification to data analysis and ending with new research projects (Follett and Strezov 2015). Consequently, it demonstrates the core value of the co-creation methodologies in collaborative design research, as it allows for the integration of different types of knowledge into the research process.

Touchpoints for Co-creation of Collaboration

Incorporating intermediate-level knowledge builds-up into the development of a knowledge platform that serves as a facilitator for sharing and evaluating knowledge. The CCM approach using touchpoints is developed with the idea to support participation at different levels of commitment and to actively involve new participants. Furthermore, it aims to promote citizen science as an equal and inclusive approach in addressing complex issues, by cultivating an active orientation on collaboration and an open contributory approach that values different types of knowledge (Friedman and Henry 2019). The CCM framework makes use of touchpoints, drawing inspiration from service design (Schneider and Stickdorn 2011), to provide multiple points of dialogue throughout the stages of collaboration. The aim of implementing touchpoints is to open up the design and research process, allowing for co-creation of the collaboration by utilizing intermediate-level knowledge emerging during the course of design and research activities.

An effective collective collaboration mapping needs to be supported by practical tools for mediated communication during the design or research process. In order to effectively map out the collaboration process, key moments need to be identified. Hence, these key moments within the collaboration would set the scene for the evaluation, reflection, and renegotiation of the necessary methods, tools, strategies, roles, ethical issues, and results, so that the collaboration process can be managed appropriately (Biesta 2010).

Marcandella et al. (2012, 124) suggest a cluster-based "assessment repository of sustainability" to support long-term collaboration. This repository serves as an educational tool for understanding collaboration through learning of a common culture and development of trust. The cluster approach involves decentralizing management and creating working groups to collaborate on projects for open innovation (Marcandella et al. 2012). Hence, the assessment repository of sustainability will enable the formation of long-term collaborative working groups based on creating links between different types of stakeholders to help them better understand the concept of collaboration. Within an Organizational Social Responsibility (OSR) framework (Marcandella et al. 2012), this assessment repository is designed to facilitate cluster management and co-sensemaking in three stages (Marcandella et al. 2012, 125):

1. Defining the studied system and related theoretical framework.
2. Creating a space for dialog about OSR and co-constructing sustainability assessment standards with the stakeholders involved.
3. Creating a renewed space for dialog.

An innovative space co-created through an assessment repository as a training medium of negotiating and balancing different types of knowledge and skills, underscores the significance of social responsibility, as elucidated by Marcandella et al. (2012). Consequently, it is through collaborative assessment efforts that these goals of social responsibility, and

equal collaboration, can create beneficial synergy of knowledge. To ensure that these goals are met, indicators should be included in the design or research process to identify key moments during the collaboration process for reflection and decision-making.

The development of "engaging indicators" as proposed by Marres and de Rijcke (2020, 1042), necessitates inclusive, equal, and interdisciplinary collaboration, involving the embedding of indicators in the design or research process. These indicators are designed or co-created moments of organization, which can influence the participation of all stakeholders in the evaluation processes of collaboration, as highlighted by Marres and de Rijcke in 2020. The concept that indicators serve a dual purpose by not only providing valuable insights into the design or research activities but also the ability to manage the active organization of communities in the making (Marres and de Rijcke 2020).

In this light, through the mapping of intermediate-level knowledge using touchpoints (Figure 2), these touchpoints would serve as indicative dialog tools. They could play an instrumental role in co-creating the collaborative environment, which encompasses various aspects such as strategies, planning, role switch, methods selection, ethical issues, mediation, interpretation, training, adaptation, and communication. Touchpoints essentially would serve as moments for directing and influencing the collaboration process, thereby in return shaping the design or research process. Touchpoints operating as an indicative dialogue tool would incorporate a "representative value" as described by Marres and de Rijcke (2020, 1042), providing insights into an inclusive collaboration within citizen science. Particularly, the deployment of touchpoints would facilitate interactions and dialogs among different points of view, data sets, knowledge types, and ways of working together. Therefore, enabling the construction of an equal and inclusive collaboration environment, that supports sharing, evaluation, and the production of knowledge. Building on this proposition, touchpoints could have an organizing role for as the collective potential of research communities in the making (Marres and de Rijcke 2020).

Summarizing, the CCM framework using touchpoints aims to co-create equal and inclusive collaboration through mapping of intermediate-level knowledge that unfolds during the design or research process. Moreover, the CCM framework aims to support the inclusion of people with different sets of knowledge types, as their collaborative involvement can be adapted to their individual context. Practically, touchpoints would embed the creation of collaboration as an extension of design or research activities.

The "Collective Collaboration Mapping" Framework

The CCM framework (Figure 2) aims to facilitate the identification of what works for an equal, inclusive, and long-term collaboration, tailored to the context of the issue, participants, and their circumstances. It draws on the OSR model (Marcandella et al. 2012) and the concept of "engaging indicators" (Marres and de Rijcke de 2020, 1042) to facilitate dialogue about the collaboration process. It outlines four touchpoints representing stages in the co-creation of

collaboration, beginning with the initial gathering of people to address an issue, to monitor the progress of the collaboration process (e.g., growth of research skills, communication, learning, networking). These touchpoints provide an opportunity for reflective dialogue to identify what works best for a collaborative, equitable, and sustained partnership.

Four Key Touchpoints

The CCM framework (Figure 2) is intended to be used as a practical guidance to co-create collaboration and suggests four key touchpoints: Sense-Making Stage, Value Stage, Innovation Stage, and Network Stage. The four open circles represent, as inspired by the OSR model (Marcandella et al. 2012), the public space in which collaboration between trained and non-trained researchers takes place. The arrows in the circles represent stages that focus either inward or outward in the collaborative process. The small white dots represent possible stakeholders, and the small black dots represent active stakeholders who are working toward collaboration. The black stars stand for active participants in the collaboration process, while the white stars indicate participants who are temporarily unable to actively take part or those who must be included to produce meaningful results.
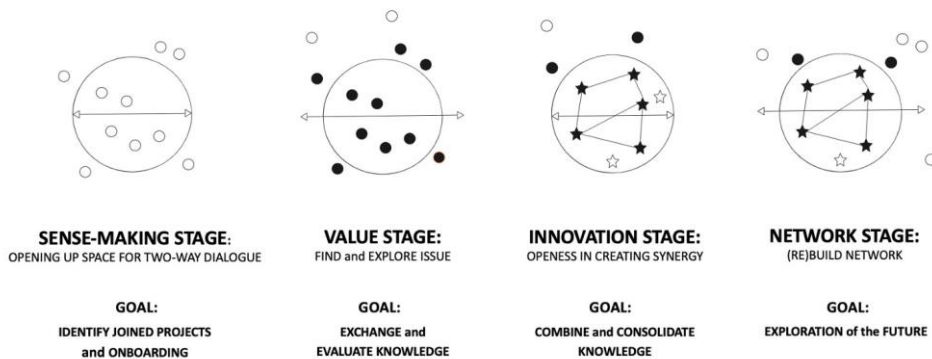

SENSE-MAKING STAGE:	VALUE STAGE:	INNOVATION STAGE:	NETWORK STAGE:
OPENING UP SPACE FOR TWO-WAY DIALOGUE	FIND and EXPLORE ISSUE	OPENESS IN CREATING SYNERGY	(RE)BUILD NETWORK
GOAL:	GOAL:	GOAL:	GOAL:
IDENTIFY JOINED PROJECTS and ONBOARDING	EXCHANGE and EVALUATE KNOWLEDGE	COMBINE and CONSOLIDATE KNOWLEDGE	EXPLORATION of the FUTURE

Figure 2: Touchpoints for "Collective Collaboration Mapping" Inspired by OSR Model
Source: Marcandella et al. 2012

Co-created touchpoints would support the collaboration process aligning with the goals of each stage using appropriate co-creation methodologies (Figure 3). This approach provides a low-threshold onboarding experience for all stakeholders (Driesche van den and Kerklaan 2022). Through the co-creation of touchpoints, stakeholders would learn an understanding of one another's languages, working styles, values, and expectations. As the needs of groups or individuals vary, interactive co-creation sessions may be flexibly tailored to offer support addressing factors such as mental health conditions, fatigue, financial challenges, social and ethical issues (Driesche van den and Kerklaan 2022).

	SENSE-MAKING STAGE	VALUE STAGE	INNOVATION STAGE	NETWORK STAGE
WHAT	OPENING UP SPACE FOR TWO-WAY DIALOGUE	FIND and EXPLORE ISSUE	OPENESS IN CREATING SYNERGY	(RE)BUILD NETWORK
GOAL	IDENTIFY JOINED PROJECTS and ONBOARDING	EXCHANGE and EVALUATE KNOWLEDGE	COMBINE and CONSOLIDATE KNOWLEDGE	EXPLORATION of FUTURE COLLABORATION
WHY	ENABLING COLLABORATION	ENABLING COLLABORATION	ENABLING COLLABORATION	ENABLING COLLABORATION
FOCUS	INDIVIDUAL EXPECTATIONS	INVOLVEMENT/ INTERESTS	TEAM COLLABORATION	SHARE VALUE FOR NETWORK
HOW	METHODS SHORT 10-60 MIN. - Research Identity Memo - Cognitive Bias Codex - Plurimodal perspective mapping - Influence Map - Mutual sympathy sessions	METHODS SHORT 10-60 MIN. - Responsibilities/Roles - Policy research - Literature study - Evaluation tools - Ideas for collaboration	METHODS SHORT 10-60 MIN. - Role play/Did you mean? - Stakeholder map - Listening sessions - Debate map on collaboration - Support role switch	METHODS SHORT 10-60 MIN. - Business model - MVP - Strong concept - Design after design - Citizen ownership
RESULT	COMMITMENT	ROUTEMAP PROCESS	RESEARCH METHODS	NETWORK

Figure 3: Stages for Co-Creating of Collaboration: Sense-Making, Value, Innovation, and Network

Each touchpoint has a specific goal and focus to enable collaboration and to accomplish its desired result(s):

▪ **Sense-making stage**: Opening up space for two-way dialogue.
- Goal: Identify joined collaborations and support of onboarding: by learning about each other's experiences, specific knowledge, motivations, to create openness and trust towards each other.
- Focus: Individual expectations, by creating room for expressing individual goals and expectations.

▪ **Value stage**: Find and explore issue (i.e., problem or challenge) as a base for insights about the value for the process of collaboration.
- Goal: Exchange and evaluate knowledge, what type of knowledge for what purpose by focusing on a design or scientific outcome and gaining insights on the value of collaboration, instead of focus on the end result of design or research.
- Focus: Involvement/interests, creating room for creating a commitment depending on how and why people want to be involved in the collaboration (i.e., value for collaboration).

- **Innovation stage**: Creating synergy of different knowledge types through collaboration.
    - Goal: Combine and consolidate knowledge, by framing the design or research process by exploring options and facilitating choices for doing the research (i.e., methods, ethical issues, roles, training).
    - Focus: Team collaboration relationships that would merge the different types of knowledge based on the context of the design challenge or research question.

- **Network stage**: (re)Build network.
    - Goal: Exploration of the future, at the end of a design or research activity the collaboration can either move to the next design or research activity, take a step back as part of the design or research process, or start new collaborations.
    - Focus: Share value for network, focus on lessons learned and future scenarios for collaboration in a responsible and sustainable way.

- **Freely usable touchpoint** (Figure 3): Emerging from the collaboration process which could be initiated by all stakeholders and participants.
    - Goal: Find opportunities or improvement for collaboration to support synergy of knowledge.
    - Focus: Defined by all involved.

The four touchpoints outline an indicative guide, since an equal and inclusive citizen science approach requires an open and flexible process. As such, touchpoints may be called upon at any given moment during the design or research process (Figure 4). Although, the order of touchpoints can be a useful guide when creating collaboration, it is important to consider which touchpoint is most relevant in the stage of the collaboration within the design or research process. For instance, to initiate collaboration, the "sense-making" stage is a logical starting point when people come together to bring about change. When a new complex problem needs to be addressed, then one or two touchpoints may be used to explore different ideas and test them in small-scale experiments. Alternatively, if communities have already taken steps towards solutions, then the 'network stage' touchpoint could be most appropriate. Nevertheless, although there is no definitive order for using the touchpoints, the suggested sequence can serve as a guide. For practical purposes and transparency of using the CCM framework it is recommended to explain the availability of touchpoints to all participants from the early beginning which could increase commitment and communication for a (long-term) collaboration process.
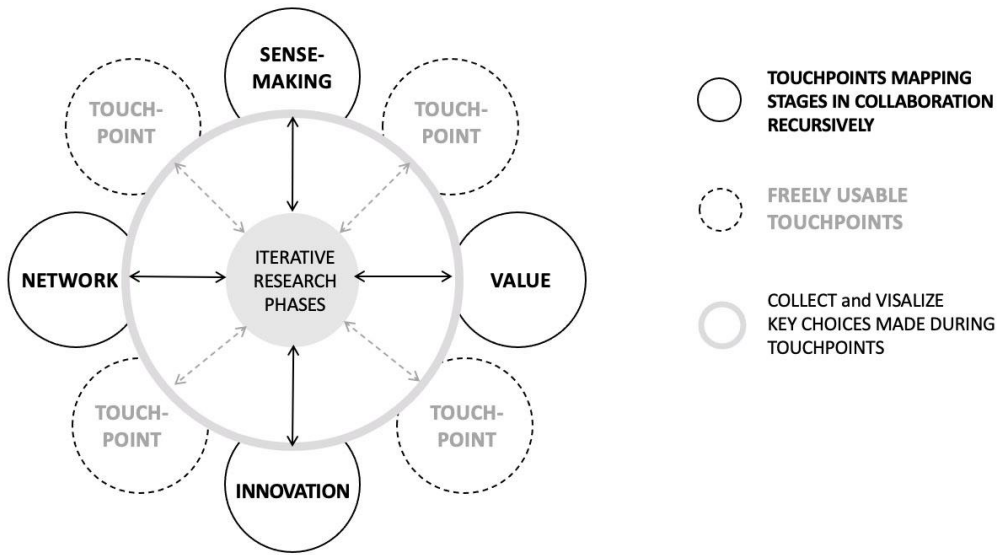
Figure 4. Options for Touchpoints at Every Phase in the Iterative Design Research Process, Including Freely Usable Touchpoints Emerging from Collaboration and Research Process

Although, touchpoints would be closely related to the phases of the design research process, they do not necessarily occur at the same time, in other words they do not run parallel. Instead, they could be used at any point of time in the design or research process because the fluidity of people participating affect the stages of collaboration. Consequently, touchpoints are influenced by the phases of the research process however the moment when they are implemented depends on the context of an issue and the situation of the collaboration.

To maintain engagement in and collective understanding of the collaboration process, creating visuals such as route maps, journey maps, flow charts, diagrams, or photo diaries could represent the essential decisions made during touchpoints. Visualizing the collaboration process could address the difficulties of sustaining consistent involvement, properly introducing new participants, and dealing with the departure of participants without compromising the progress of the process (Driesche van den and Kerklaan 2022). Additionally, by visualizing the mapping of insights decided on at each touchpoint that guided the collaboration process, participants gain a sense of ownership and develop a stronger connection to the research process, communication, and activities (Driesche van den and Kerklaan 2022).

In summary, using touchpoints in co-creating collaboration has the potential to grant an equal involvement and commitment to the design or research process, by staying informed about the production of knowledge and the skills gained throughout the collaboration. They would provide stakeholders and participants with the practical ability to monitor emerging intermediate-level knowledge in a bottom-up way, allowing for a multitude of perspectives

on the direction of the collaboration process. Additionally, integrating touchpoints in the design or research process, could be guidance to provide a means of training, and sharing lessons learned, which encourages participants to (re-)join and/or switch research roles (Vaughn and Jacquez 2020). Touchpoints would serve as a dialogue tool to co-create collaboration through opening up the design or research process and generate new knowledge through collectively mapping this process.

Concluding Remarks

The projective of this theoretical and conceptual CCM framework is to enable trained and non-trained designers or researchers to navigate the complexities of co-creating a collaborative process that is equal and inclusive. It provides an opportunity for predetermined design or research plans to be opened up, thereby allowing for all types of knowledge to be included, shared, evaluated, and integrated, through co-creation of collaboration. Touchpoints would form a practical tool to consider, describe, combine, and renegotiate the selection of methods, tools, time, roles, ethical issues, and (provisional) outcomes, to support equal collaboration. Through these co-created touchpoints, participants would be able to define their way of collaborating, in addition to being involved in design or research activities.

The CCM framework aims to go beyond the traditional contributory approach by providing trained and non-trained researchers and project leads the opportunity to drive collaborative initiatives from the bottom up. Co-creation of the collaboration process suggests a recursive process of knowledge production through monitoring and assessment of intermediate-level knowledge during indicative moments in the collaboration process. The mapping of intermediate-level knowledge aims to disclose the recursive character of the design process, thereby unlocking the potential to create synergy of different types of knowledge. Consequently, this paves the way for the establishment of an intrinsically circular flow of knowledge production through co-creation.

Further research is imperative to address the numerous outstanding questions relating to the co-creation of collaboration. To enhance the applicability of the CCM framework in real-world citizen science projects, it is essential to provide guidelines and practical examples. These guidelines should include specific recommendations for effectively facilitating touchpoints, managing collaboration dynamics, and promoting the creative process. More in-depth research has to be done on the challenges in citizen science collaboration, such as ethical issues, motivation, roles, and communication. A thorough discussion of potential obstacles and strategies to overcome them is necessary to enhance the practical relevance of the framework.

Additionally, a comparative analysis between the CCM framework and existing design or research approaches, as well as an evaluation of its effectiveness compared with alternative collaborative frameworks. It is also important to consider the complexities of involving long-

term participants by assessing and ensuring the accuracy of the final design or scientific outcome. Moreover, the CCM framework should be assessed to determine if it is more beneficial for citizens, trained researchers, or project leads, and whether it can support the switch between different roles in citizen science. A key opportunity for continued study is to explore how the process of collaboration could be digitized using self-tracking tools, allowing stakeholders and participants to explore their onboarding experiences and needs, and how these inform the co-creation of collaboration. Another opportunity would be to explore the generalizability of the CCM framework to different contexts or domains, beyond citizen science.

To conclude, the value of co-creating the collaboration process for an equal and inclusive citizen science approach suggests an important role for co-creation methodologies and reflective dialogue during touchpoints. Collective collaboration mapping can provide guidance for this bottom-up arrangement of reflective moments, leading to the creation of "knowledge commons" within a recursive CCM framework.

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Conflict of Interest

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