

A NEW RESEARCH PROTOCOL FOR USING SYSTEM MAPS IN SYSTEMIC DESIGN RESEARCH

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ABSTRACT

System maps are established tools in design practice and education as well as non-design research, both as a process and an outcome of systemic analysis and synthesis. Applying causal loop diagrams (CLD's) in (systemic) design research could be of great value to tackle the growing societal complexity. At this moment there is, however, no clear research protocol to include the rich data necessary for systemic research and ensure a scientifically valid system map in the context of design research. In this paper, we propose a protocol using CLD's as a research method and outcome in design-inclusive research. The protocol synthesises rich data from qualitative research in a way that the representation yields higher validity compared to the regular approach to systems mapping, using a process of reflection and iteration on boundary setting. An iterative process of qualitative research methods with lean validation methods was used to come to a conceptual proposal. The protocol can support systemic design researchers and practitioners to include a scientifically grounded CLD in the explorative research actions phase, thus bridging the research towards a phase of creative design actions.

Keywords: Design practice, Research methodologies and methods, Complexity, Systemic design, Causal loop diagrams

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1 INTRODUCTION

Since the introduction of the concept 'systemic design' (Jones and Bowes, 2012), the system map as a tool for synthesising information and providing a visual overview of the system has become more and more widespread in design practice. Jones and Van Ael (2019) provided the design community with the Systemic Design Toolkit, where the causal loop diagram (CLD) is an indispensable tool in 'Understanding the System'. The Design Council suggests using systems mapping in the Explore stage of the design process in their publication *Beyond Net Zero: A Systemic Design Approach* (Design Council, 2021). Peter Stoyko contributed with a visual language for systems thinking as it relates to interdisciplinary, collaborative design in his research project SystemViz (Stoyko, 2022).

The growing prevalence for system mapping as an essential design tool for both practitioners and design educators becomes visible throughout design projects and educational programmes. The Oslo School for Architecture and Design (AHO) uses gigamapping in various systems-oriented design courses (Sevaldson, 2022). OCAD University in Toronto works with synthesis maps in their Strategic Foresight and Innovation Systemic Design course, guided by Peter Jones and Jeremy Bowes (Strategic Innovation Lab, 2022). At the University of Antwerp, a significant part of the Systemic Design Module for master students in Product Development involves making an understanding CLD's.

With regard to research activities, system mapping and CLD's found their way in research fields such as public health (Sahin et al., 2020; Niks et al., 2022; Paina et al., 2014; Gillen et al., 2014; Werner et al., 2021; Allender et al., 2015), sustainability transitions (Amrina et al., 2021; Mies and Gold, 2021; Salvia et al., 2022) and policy design (Gudlaugsson et al., 2022; Sutanto et al., 2008; Zhou et al., 2022). CLD's as a research method are used for different research purposes: (1) to analyse complex problems (Shoar and Payan, 2022; Salvia et al., 2022; Amrina et al., 2021); (2) to engage stakeholders in the research process (Gillen et al., 2014; Inam et al., 2015; Allendar et al., 2015); and, to a lesser extent, (3) to measure the effect of interventions in complex socio-technical systems (Cassidy et al., 2021; Richards et al., 2021; Zhou et al., 2022). We can conclude that CLD's as a research method are well established.

In the context of design sciences, however, and more specifically in the context of design-inclusive research, only few examples can be found using system mapping as a research means. Nevertheless, both the characteristics of the problems addressed in systemic design and the nature of design-inclusive research require research methods that can handle the rich data and the relations between data. In order to do so, applying systems mapping and CLD's in design-inclusive research requires the approach to be scientifically sound. At the same time and following the principle of reflexive practice (Reich, 2017), (systemic) design research can benefit from a designerly way to frame research and gather and analyse data. Horváth (2008) describes the methodology of design inclusive research as a three-phase process: a phase of explorative research actions, a phase of creative design actions and a phase of evaluative research actions. By introducing the development of a CLD in the explorative research actions phase, a (systemic) design mindset is incorporated early in the research, and the way is paved for an enriched phase of creative design actions. A scientifically grounded systemic approach to design-inclusive research could be the missing puzzle piece, connecting the established use of CLD's as a research method in other scientific fields with design research and design practice.

In this paper, we aim at formulating a protocol for system mapping in order to use it as a research method and research outcome in design-inclusive research. Qualitative research methods and systemic design tools are combined into an enriched research approach for systemic design-inclusive research, building on Horváth (2008). The aim is to produce a higher validity compared to the regular approach to systems mapping. This research confines itself to the use of CLD's, a kind of system map where the focus lies on the causal relations between variables of the system: causal loops of these variables are built, connecting different loops into a visual representation of the system. In other system maps, the relation between elements is not limited to causality, e.g. visualising power relations or exchange relations between actors. Firstly, the journey that led to this protocol is mapped out under the section Methods. Secondly, the protocol, the underlying principles and how to use it, are described in Results. Lastly, the Discussion and Conclusion section reports on first learnings and suggests further research

opportunities based on this protocol. Design researchers and practitioners are invited to use this research to build more scientifically grounded CLD's.

2 METHODS

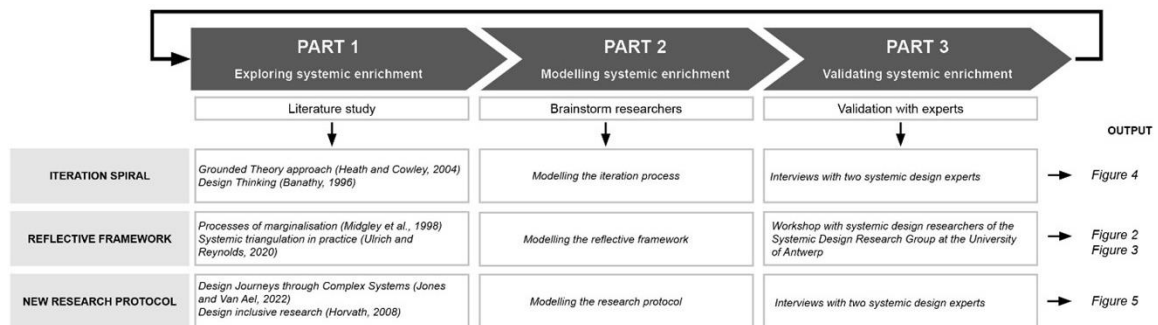


Figure 1. Overview of used research methods

Today, the quality of CLD's is measured through its applicability in a further design or research process, accordingly providing useful insights that might steer next design steps. In the context of design research, there is a need for more scientifically grounded methods during all map making phases. The overall objective of the protocol is to validate and enrich data in every step of systemic design research. To that end, an iterative process of qualitative research methods was used existing of three parts: (i) exploring systemic enrichment, (ii) modelling systemic enrichment, and (iii) validating systemic enrichment (Figure 1). As the new research protocol is substantiated by and depending on a reflective framework and iteration process, the three concepts are developed simultaneously. In the exploration phase, relevant literature was gathered to provide a theoretical basis. Secondly, the researchers started modelling conceptual frameworks based on the provided theory. Lastly, a lean validation approach was sought, including interviews with two systemic design experts and a workshop with systemic design researchers of the Systemic Design Research Group at the University of Antwerp. The research protocol presented in the results section is a conceptual proposal. Although the first steps towards validation have been taken, in future research, a richer data input and more extensive validation process is aspired.

3 RESULTS

The proposed protocol for systemic design research consists of two main elements: a data gathering and analysis part, and a data synthesis part. The first part (data gathering and analysis) includes three cycles: (i) defining the purpose and perspective of the research; (ii) framing the system for data input and (iii) data gathering and analysis. Qualitative research methods are enriched with systemic design methods. Suggestions for systemic tools for enriching the data are made and iterative data gathering cycles are recommended. In the second part (data synthesis), systemic design methods are enriched with qualitative research methods. Starting from a CLD as a research outcome, the concept of systemic triangulation (Ulrich and Reynolds, 2020) is used. A last cycle bridges the explorative research phase with a creative design phase, which could lead to further design inclusive research or to projects in design practice. In this last cycle, recommendations to enrich the insights emerging from the system map are given, suggesting different ways to 'read' the system map, depending on the further journey in research or practice.

3.1 Overview of key concepts

Prior to discussing the different cycles of the protocol, four key concepts need to be clarified. They were used to build the framework for the protocol and add to its validity and quality. Firstly, the idea of systemic triangulation (Ulrich & Reynolds, 2020) is explained, together with the work of Midgley (1998), that adds to Ulrichs research with 'processes of marginalisation'. Secondly, the Systemic Design Toolkit of Jones and Van Ael (2022) and its complementarity with this protocol for systemic design research is discussed. We briefly talk about leverage analysis (Murphy and Jones, 2020) as a language to deepen the insights of a system map. Lastly, we discuss how Noel's Positionality Radar (Noel and Paiva, 2020) is used as a tool to be conscious about the perspective of the researcher in the research.

3.1.1 Systemic triangulation and processes of marginalisation

In its most simple shape, the protocol is a process of critical reflection and iterative adaptation on the boundaries and the components of a system. The foundations of this boundary critique were laid by Churchman, and they were developed further by Ulrich and Midgley (Midgley et al., 1998). Donella Meadows described this process of boundary setting sharply: "If we're to understand anything, we have to simplify, which means we have to make boundaries" (Meadows, 2008, p.97). Boundary setting in the context of research means to evaluate which facts (observations and the relations between those observations) and values (the multiple perspectives of multiple stakeholders) have to be included in the research scope and which do not. By wisely making these scoping decisions, and making them valid throughout the research process, the concept of boundary critique could strengthen and ground the research. For this purpose, Ulrich proposed an eternal triangle of boundary critique, visualising the constant interdependence between facts, values, and boundary judgements (Ulrich, 1998).

His writings are found to be central to this research: essential in the protocol is a constant critical attitude of the researcher towards the object of research by reflecting on it from different perspectives. The eternal triangle is adapted (Figure 2) to include 'purpose' (what is the purpose of the research and how does it change throughout the process?) and 'perspective' (what effect does the perspective of the researcher and the stakeholders have on the facts and values presented?). By using the triangle in all protocol cycles, the idea of 'systemic triangulation' is put into practice. Ulrich defines this concept as "the methodical employment [of the triangle] for critical purposes (...) by combining different databases (judgements of fact) with different reference systems (boundary judgements) and value sets (judgements of value) so as to gain a deeper understanding of the selectivity of claims." (Ulrich and Reynolds, 2020, p.296). To facilitate putting systemic triangulation in practice, reflective questions based on the triangle are asked throughout every cycle of the protocol, evaluating the cycle and preparing the research for the next step (see Figure 3 for a complete overview of the questions and Figure 5 for an overview of which questions are used in which cycle). Each cycle of the protocol has a different focal point in the triangle, depending on the research stage. In using systemic triangulation throughout the protocol, the research is enriched with a systemic mindset and the insights will be well grounded in the real world, paving the way for creative design actions that do not disregard its inherent complexity.

Some of the reflective questions are based on Midgley's work on processes of marginalisation. His writings expand on Ulrich's research with the question: "what happens when there is a conflict between groups of people who have different ethics (values in action) relating to the same issue, and thereby make a different boundary judgement?" (Midgley et al., 1998, p.469). He stresses both the importance of considering (unintended) exclusion dynamics when involving stakeholders in the process of boundary setting, and taking 'silent' actors into account, those that are not directly affected or involved, but could have an important perspective to bring to the boundary judgement (Midgley et al., 1998). Taking these actors into account broadens the perspective of the researcher and enriches the collected data: they can provide essential information that fuels the significance of the system map. Therefore, reflective questions 9 and 23 (Figure 3) in cycle 1, 3 and 4 (Figure 5) focus on these processes of marginalisation.

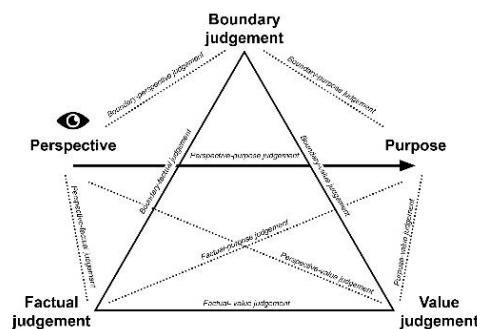


Figure 2. Enriched boundary critique, adapted from Ulrich, 1998.

	Boundaries	Facts	Values	Purpose	Perspective
Boundaries	<p>1. Did we include all relevant variables? Did we exclude all irrelevant variables?</p> <p>2. Within the framework of your problem, how will the boundary judgement have an impact on the actions to effect change?</p>	<p>3. What method was used to decide which facts are included and which are not?</p>	<p>4. In what way may our reference system fail to do justice to the perspective of different stakeholder groups?</p> <p>5. In what way does the boundary judgement serve some actors better than others?</p> <p>6. Did the process of coming to consensus about boundary setting involve a process of marginalisation between the involved/affected stakeholders?</p> <p>7. How did the stakeholders have a say in the process of boundary setting?</p>	<p>8. How does the purpose of the research affect the boundary setting?</p>	<p>9. If boundaries are set based on the consensus of all affected or involved stakeholders, which other (silent) actors could still have an important perspective on the boundary judgement?</p>
Facts		<p>10. How is literature used in the making of the system map? Are the variables obtained by research that meets the standards for a thorough literature review?</p> <p>11. How is the data analysed? Does the analysis meet the standards for qualitative data analysis?</p> <p>12. Which methods were used to enrich the data with a systemic perspective? How did these methods enrich the data?</p>	<p>13. Did the considering of new facts lead to a rethinking of value judgements?</p> <p>14. Did modifying our value judgements lead to new relevant facts?</p>	<p>15. How did considering new facts lead to rethinking the purpose of the research/system map?</p> <p>16. How did rethinking the purpose of the research/system map lead to new facts?</p>	<p>17. How did the perspective of the researcher influence the importance of certain facts over others?</p> <p>18. How did the perspective of a stakeholder group influence the importance of certain facts over others?</p>
Values			<p>19. Does the pool of interviewees include both involved and affected stakeholders?</p> <p>20. How were power dynamics taken into account when choosing the stakeholders to be interviewed?</p>	<p>21. How did involving new stakeholders lead to rethinking the purpose of the research/system map?</p> <p>22. How did rethinking the purpose of the research/system map ask for involving new stakeholders?</p>	<p>23. Did the process of coming to consensus about the system map involve a process of marginalisation between the involved/affected stakeholders?</p>
Purpose				<p>24. What do you want to achieve with this research/system map?</p> <p>25. Who are the beneficiaries of this research/system map?</p> <p>26. Who will be affected by this research/system map?</p>	<p>27. How does the positionality of the researcher have an impact on the purpose of the research?</p>
Perspective					<p>28. How does the positionality of the map maker/facilitator have an impact on the choosing process of the interviewees?</p> <p>29. How did the researcher examine their own bias based on their positionality?</p> <p>30. Who is the commissioner? How does the commissioner have an impact on the preliminary boundary judgement?</p>

Figure 3. Reflective questions

3.1.2 Causal loop diagrams in the systemic design toolkit

In cycle four, a system map is created out of the data gathered in the previous cycles. Making a CLD is a technical activity that needs practice. Jones & Van Ael describe the specificities of this process in their book *Design Journeys Through Complex Systems* (2022, p.108-111) and provide useful tools to practise making CLD's. It is emphasised that designing a system map is a group activity: the researcher acts as 'data owner' and facilitator, while other researchers, designers or experts can take up the role of critical map makers, who have a new perspective on the data and its interconnections. Besides the instructions to make CLD's, other tools from the book are recommended, for example the Actor Network Map (Jones & Van Ael, 2022, p.50-53) and tools to conduct interviews in cycle 2 (Jones & Van Ael, 2022, chapter 2: Listening to the system, p.65-89).

3.1.3 Leverage analysis

There are many ways to 'read' a CLD and gain insights from it. Depending on the next step in the research, different analyses can be conducted: for research in transition processes, an analysis on boundary judgement level could be interesting, or the CLD can be examined for controversy spillovers (Cuppen et al., 2020). For research in service design, a version of the actor network map as an overlay on the CLD could provide insights to which stakeholders have leverage for change. Regardless of the chosen path, it is essential to use a common language in this sense-making process of systemic design research. In this protocol, we propose to use leverage analysis as a common language. This concept was introduced by Murphy and Jones (2020) as a set of tools from graph theory (the mathematical study of structured relations between objects) to analyse systemic design models. By using leverage analysis as a common language, triangulation as a validation method is possible, as is expert validation, elevating the quality of the gained insights and thus the quality of the overall research.

3.1.4 Positionality

To capture the perspective of the researcher(s) and map maker(s) and its impact on the research, it is recommended to use Lesley-Ann Noels Positionality Radar (2020). Factors like age, multiculturality, social class and gender are scored and compared with other team members, thus creating a visualisation of the positionality of the researcher(s). With this tool, exclusion areas are easily recognisable, prompting the researcher to reevaluate the boundaries of the research and, if necessary, to include other perspectives via stakeholder engagement. In general, the quality of the research will benefit from making the bias of researcher(s) and map maker(s) explicit. The reflective questions 17, 18, 27-30 (Figure 3) in cycle 1 and 4 (Figure 5) focus on positionality.

3.2 Overview of the protocol for systemic design research

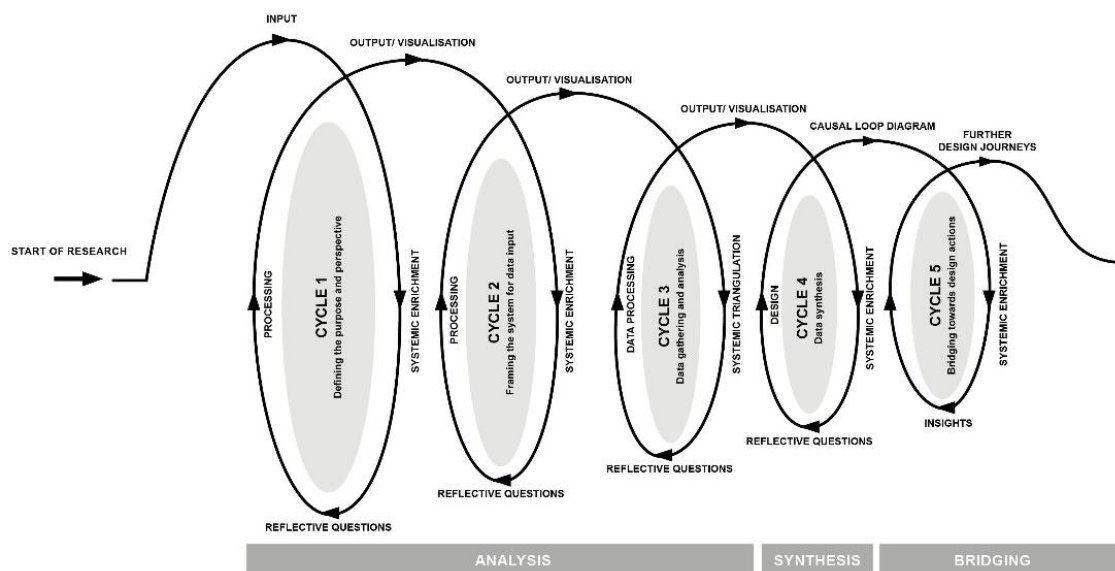


Figure 4. The iteration spiral

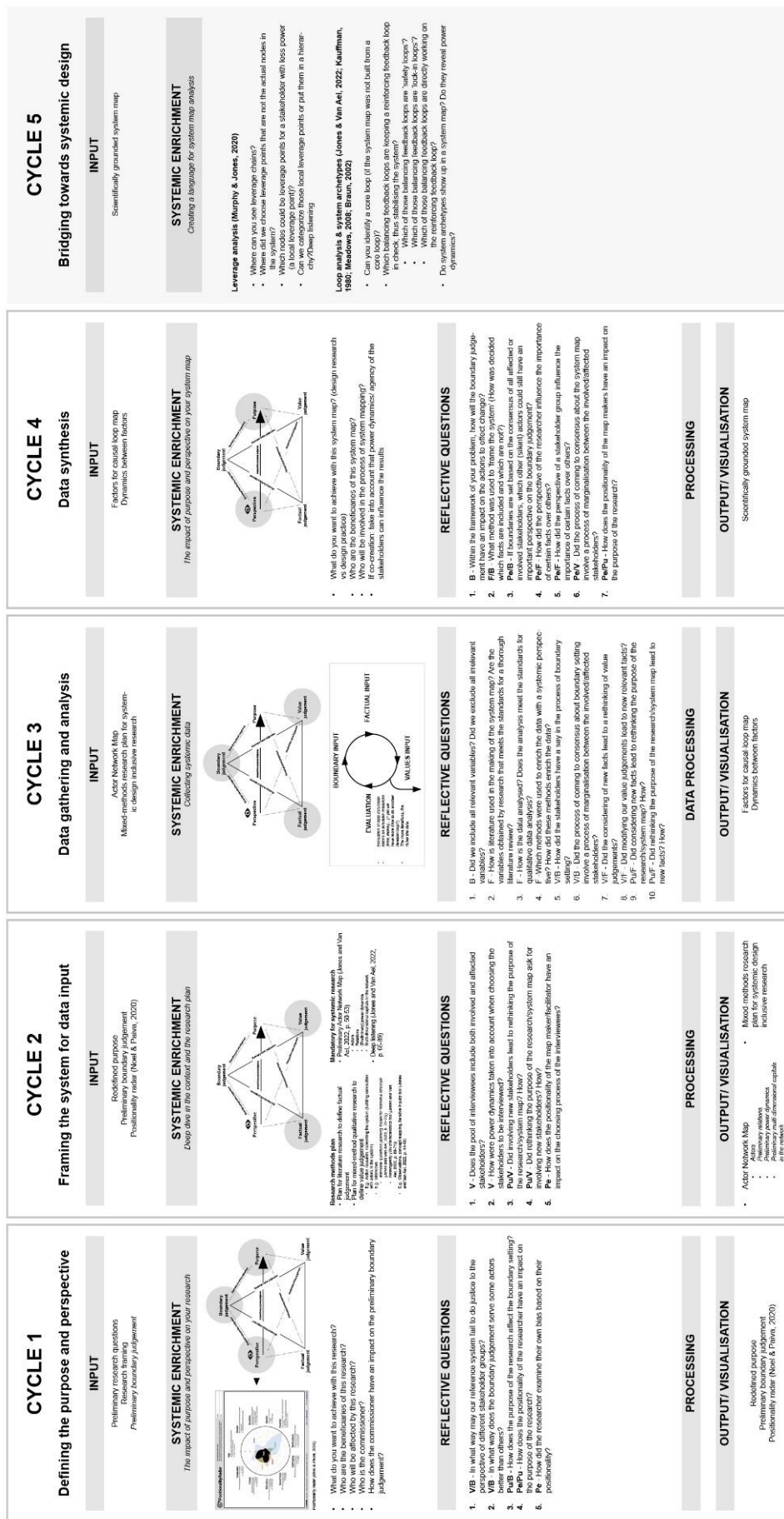


Figure 5. Overview of research protocol

3.2.1 Cycle 1: defining the purpose and perspective of the research

Before starting cycle one, the researcher should have a set of preliminary research questions, a research framing or scope and a preliminary boundary judgement. There will not be any data available yet, so in this cycle the emphasis will be on the impact of purpose and perspective on the boundary judgement. The researcher will go through the enriched boundary critique triangle for the first time and fill in the positionality radar (Noel & Paiva, 2020). Via the reflective questions, the researcher can examine how their own perspective and the perspective of the commissioner could have an impact on both boundary setting and the involvement of all stakeholders. The output of this cycle will be a well-defined research purpose, a preliminary boundary judgement and the positionality radar.

3.2.2 Cycle 2: framing the system for data input

In cycle two, a plan for data gathering is made and the research methods are chosen. In this cycle, the central question is: how can all stakeholders be involved and how will this affect the gathered data? Both qualitative research methods and systemic design methods are proposed, and it is suggested to mix methods: for example, use the stakeholder characteristics tool from Design Journeys Through Complex Systems (Jones & Van Ael, 2022) together with semi-structured interviews. Two tools are strongly recommended when doing systemic design research: the actor network map and techniques for deep listening. When a plan is defined, the researcher can answer the reflective questions and, if necessary, remake the plan. The output of this cycle will be a mixed-methods research plan for design inclusive research and a preliminary actor network map.

3.2.3 Cycle 3: data gathering and analysis

When gathering and analysing data in systemic design research, it is recommended to constantly reflect on boundary judgement, factual judgement, and value judgement. The data gathering will be conducted in iterative cycles, judging and rejudging if new facts lead to new values, which might demand a rethinking of the boundaries of the research. The reflective questions in this cycle can help with this iterative process, which will become richer with every data gathering cycle. The researcher decides to go to the next cycle when they reach a data saturation point (no new information is collected), or when the available resources are exhausted. The output for this cycle will be a list of factors to build a CLD and information about the dynamics between those factors.

3.2.4 Cycle 4: data synthesis

In cycle four, all data comes together in a CLD. This data is both enriched by using systemic design tools and grounded: it meets the standards for sound scientific research. Before the CLD is built, a last round of reflection about purpose and perspective is necessary. Apart from synthesising data, the CLD could for example be used for stakeholder engagement in a later stage of the research. The positionality and perspective of the makers of the diagram also influence the research results. The reflective questions in cycle four revolve around these questions of purpose and perspective. The output of this cycle will be a scientifically grounded CLD.

3.2.5 Cycle 5: bridging towards design actions

Cycle five is the bridge between the analysis and synthesis of data, and a phase of creative design actions. Depending on the kind of research, different analyses are possible. As mentioned above, it is key to find a common language for extracting insights from the CLD. Leverage analysis (Murphy & Jones, 2020) is suggested for this purpose, as well as loop analysis (Meadows, 2008; Kauffman, 1980) and system archetypes (Braun, 2002).

4 DISCUSSION & CONCLUSION

CLD's as a research method are used for different research purposes: (1) to analyse complex problems; (2) to engage stakeholders in the research process; and, to a lesser extent, (3) to measure the effect of interventions in complex socio-technical systems. Substantiated by these objectives, CLD's present a potentially valuable research method in systemic design research to embrace and tackle the growing complexity of the problems designers are facing. In this paper, we proposed a protocol for the design of CLD's as a research method and research outcome in design-inclusive research. The

enriched approach for system mapping synthesises rich data from qualitative research in a way that the representation yields higher validity compared to the regular approach for systems mapping. By building on key concepts such as systemic triangulation (Ulrich and Reynolds, 2020), a new research protocol is proposed with the focus on reflection in an iterative process. In this process, boundary, value and factual judgement, purpose and perspective are constantly reevaluated. In five cycles, the design researcher is guided through the data gathering and analysis and data synthesis, resulting in a scientifically grounded CLD. Throughout the research process leading to the CLD, we invite them to open their perspective and use systemic design actions to enrich the data. The last phase of the protocol is the bridge between the analysis and synthesis of data towards creative design actions. Depending on the kind of research, different analyses are possible. The proposed protocol for systemic design research is still in a conceptual phase. Limits to this exploratory study need to be acknowledged, most notably the limited data from validation of the protocol in practice. Future investigations are necessary to test the protocol, but also to build on it and expand it: in cycle four, other methods for systemic synthesis than the CLD could be included. In cycle five, methods for enriching the system map with overlays of other maps and approaches (actor network map, transition layer, ...) could be added. To conclude, we want to note that the protocol brings value to (systemic) design researchers as well as design practitioners and design educators, as they can all benefit from a more substantiated way of designing system maps. By working in short experiment-evaluation loops, a constant interaction between research, practice and education is possible. If this protocol could be enriched with new insights and validated with more data, a foundation is laid for a new design research method that enables system map comparison for systematic review, resulting in meta-level learning about dealing with complexity.

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