ICIS 2024 Proceedings

International Conference on Information Systems (ICIS)

December 2024

Approaching Visual Inquiry Tools through the Lens of Systems Thinking: the Proposal of a Digital Inquiry Platform

Alicia Roschnik
Faculty of Business and Economics (HEC), University of Lausanne, alicia.roschnik@unil.ch

Dominique Jaccard
University of Applied Sciences of Western Switzerland (HEIG-VD), dominique.jaccard@heig-vd.ch

Sandra Monnier
University of Applied Sciences of Western Switzerland (HEIG-VD), sandra.monnier@heig-vd.ch

Stephanie Missonier
University of Lausanne, stephanie.missonier@unil.ch

Approaching Visual Inquiry Tools through the Lens of Systems Thinking: the Proposal of a Digital Inquiry Platform

Completed Research Paper

Alicia Roschnik
Faculty of Business and Economics (HEC), University of Lausanne
Lausanne, Switzerland
alicia.roschnik@unil.ch

Dominique Jaccard
University of Applied Sciences of Western Switzerland (HEIG-VD)
Yverdon, Switzerland
dominique.jaccard@heig-vd.ch

Sandra Monnier
University of Applied Sciences of Western Switzerland (HEIG-VD)
Yverdon, Switzerland
sandra.monnier@heig-vd.ch

Stéphanie Missonier
Faculty of Business and Economics (HEC), University of Lausanne
Lausanne, Switzerland
stephanie.missonier@unil.ch

Abstract

Today's landscape is shaped by wicked problems, characterised by their uniqueness and diverse stakeholders. While Visual Inquiry Tools have emerged to help address these problems in a collaborative and non-linear way, they fall short in providing both a holistic and detailed view of the problem and solutions, and they fail to account for evolving information. Additionally, their paper-based nature limits the collaboration of geographically dispersed stakeholders. All of which are inherent characteristics of wicked problems. Recognising these limitations, in this study, we explore how systems thinking can enhance Visual Inquiry Tools. We conduct a design science research project to integrate systems thinking into Visual Inquiry Tools through digitalisation, resulting in co.LAB, an open-access Digital Inquiry Platform usable for IS scholars and practitioners alike. This research contributes to advancing IS research, deepening our understanding of how systems thinking, Visual Inquiry Tools, and digitalisation can intersect to help tackle wicked problems.

Keywords: Visual inquiry tools, systems thinking, digital inquiry platform, wicked problems

Introduction

Driven by the growing interconnectedness and complexity enabled by, amongst others, digital technologies, today's landscape is increasingly shaped by what are known as "wicked" problems (Grewatsch et al., 2023; Rittel & Weber, 1973). Examples of such problems are social-ecological transformations (Sediri et al., 2020) or at an enterprise level, large-scale agile transformations (Roschnik & Missonier, 2024). These problems are characterised by their uniqueness, complexity, and diverse stakeholders from multidisciplinary horizons with contrasting or even opposing viewpoints. The process of formulating and resolving these problems is arduous as there is no single nor definitive understanding of neither the problem nor the potential solutions. Adding to the complexity is the interconnectedness of these activities, with each feeding information to the other (Buchanan, 1992; Rittel & Weber, 1973). Due to their ill-defined nature, such problems defy conventional and linear problem-solving paradigms and rather, require to be approached with social-oriented practices (Hawryszkiewycz, 2014). In response to these challenges, a type of artefact termed "Visual Inquiry Tool", has gained traction and been theorised (Avdiji et al., 2020). Developed to help address wicked problems through collaborative, engaging, and socially oriented practices, these tools provide a canvas for exploring and tackling wicked problems visually and in a non-linear way (Avdiji et al., 2020). Notable Visual Inquiry Tools include the Business Model Canvas (Osterwalder & Pigneur, 2011), Team Alignment Map (Avdiji, 2018) and more recently, the Public AI Canvas (Fatima et al., 2022) and the Agile Team Canvas (Roschnik et al., 2024).

However, upon examining the characteristics of wicked problems (Rittel & Weber, 1973), we find that Visual Inquiry Tools need further development to accommodate the following aspects inherent to wicked problems. First, existing Visual Inquiry Tools are designed as material artefacts, based on a "paper-based" approach, where its users employ post-its (i.e., sticky notes) on a printed version of the canvas to work on it. This physical characteristic limits the collaboration and coordination of the diverse stakeholders (i.e., users of the Visual Inquiry Tool) who are not necessarily collocated, especially as part of today's highly digital environment (Benbya et al., 2020). Second, the current form of Visual Inquiry Tools does not accommodate the different perspectives held by multidisciplinary stakeholders concerning the problem. Indeed, as is, Visual Inquiry Tools are limited in their ability to portray the different interconnected relationships, thus hindering the attainment of a holistic understanding of the problem and envisioned solutions. Third, the static nature of Visual Inquiry Tools limits the users' capacity to take into account new or updated information regarding the problem formulation or its resolution, which in wicked problems are intertwined and subject to change (Rittel & Weber, 1973). Despite that some existing Visual Inquiry Tools such as the Business Model Canvas (Osterwalder & Pigneur, 2011) have been implemented on commercially available platforms like Miro.com, these primarily involve "digitising" a physical object into a digital format encoded into bitstrings (Baiyere et al., 2023) as such type of platform is essentially the digitisation of a whiteboard (Chan et al., 2023). Although digitising a Visual Inquiry Tool by implementing it onto Miro may address the remote collaboration issues, it does not speak to the integration of different perspectives by allowing to alternate between views for deeper exploration (e.g., holistic view, detailed view, view of the interrelations). Indeed, as is, Visual Inquiry Tools implemented on platforms such as Miro are limited in their ability to portray the different interconnected relationships and hence impede the attainment of both a holistic and detailed understanding of the problem and envisioned solution. Furthermore, as platforms such as Miro do not allow for interrelationships and feedback loops, they are less suitable for considering emerging changes (e.g., new information) which are inherent to wicked problems as both their formulation and resolution are intertwined and are subject to change (Rittel & Weber, 1973). Recognising these limitations and motivated by the widespread adoption of Visual Inquiry Tools across both IS scholars (e.g., vom Brocke and Maedche (2019)) and industry (e.g., Fatima et al. (2022)), **our objective in this study is to explore how these tools can further account for the intrinsic nature of wicked problems**. Specifically, our focus lies on assessing how these tools can accommodate emergent information and diverse perspectives whilst portraying the various interconnected relationships to allow for a holistic view of the problem and solutions. Additionally, we aim to facilitate collaboration and coordination among the geographically dispersed stakeholders.

To meet the objective of this research, we draw on systems thinking, which has a long-standing history in the IS discipline (Checkland, 1988; Hirschheim, 1983), with calls for a more systemic perspective on IS research dating back to 20 years ago (Alter, 2004). Yet, despite these calls, systems thinking has not seemed to have made its way (Demetis & Lee, 2016; Hassan, 2023). However, in recent research, systems thinking has been suggested as a valuable paradigm for addressing different wicked problems (e.g., Grewatsch et al., 2023; Harsaae et al., 2023). One promising avenue for integrating systems thinking into Visual Inquiry Tools lies in "digitalisation", which goes beyond the mere "digitisation" of an artefact as it speaks to the broader context of the digital artefact such as its use case (Baiyere et al., 2023). To do so, we design, implement, test and evaluate a prototype of a **Digital Inquiry Platform** named **co.LAB** using Design Science Research (Hevner et al., 2004) as our overarching research paradigm. Specifically, we leverage the existing literature on systems thinking (Matook & Brown, 2016) to formulate design principles (Gregor et al., 2020) that we then instantiate into co.LAB. Our evaluation of co.LAB involves a simulation-based benchmarking of artefacts (Prat et al., 2015), comparing it against an instantiated paper-based Visual Inquiry Tool and its digitised version on Miro.com. Co.LAB is a collaborative open-access web-platform that accommodates the digitalisation of different Visual Inquiry Tools. It integrates systems thinking into

Visual Inquiry Tools by supporting the systemic and dynamic representation of interconnected dimensions of the problem. It does so by allowing its users to switch between different views of the problem, alternatively focusing on elements of solutions or relationships between those elements. Furthermore, co.LAB offers new possibilities for collaboration (e.g., collaborative writing or collaboration within geographically dispersed teams) and coordination (e.g., assigning tasks).

This study presents the following contributions. First, we anticipate that our research could significantly impact the field of IS, by offering a new perspective on addressing wicked problems prevalent as part of our increasingly complex world. Second, by bridging systems thinking and Visual Inquiry Tools, the study opens up new avenues for addressing real-world problems as we shift the paradigm from a tool-centric to a system-centric lens within Visual Inquiry Tools. We therefore contribute to the growing literature on visual inquiry and established literature on systems thinking by closely linking the two bodies of literature. Third, we contribute to the design knowledge by proposing an instantiated and evaluated artefact (co.LAB) designed based on design principles formulated and formalised by drawing on Gregor et al. (2020). In terms of practical implications, the proposed Digital Inquiry Platform is open-access and can thereby be used by both scholars and practitioners to implement and use existing or novel Visual Inquiry Tools in their daily work.

The remainder of this article is as follows. First, we provide the background related to Visual Inquiry Tools, highlight the existing shortcomings in current Visual inquiry Tools and conclude the section by providing the theoretical grounding for the study. In the following section, we describe the research approach consisting of the problem and solution spaces of the study. Subsequently, we describe the designed artefact and following this, we present its evaluation alongside the results. Moving forward, we discuss the implications, contributions, limitations, and avenues for future research. Finally, in the last section, we provide a brief conclusion of this research paper.

Background

Visual Inquiry Tools for Wicked Problems

In their seminal research paper, Rittel and Weber (1973) describe the characteristics of wicked problems. These problems are inherently unique and defy definitive formulation as both their formulation and resolution are intertwined. They are prone to new and incoming information, with stakeholders alternating between problem formulation and resolution. Furthermore, they pose challenges in understanding and resolving them by lacking a stopping rule, thereby perpetually engaging problem solvers in the quest for improvement. They call for diverse reasoning and lack immediate verification, with consequences unfolding over time and impacting future iterations. Finally, addressing wicked problems aims at enhancing aspects of the world rather than uncovering absolute truths. An example of a notorious wicked problem is the war on drugs (Alford & Head, 2017), or in the IS literature, the wickedness of designing IT for integration work (Haj-Bolouri, 2021) or of conducting large-scale agile transformations (Roschnik & Missonier, 2024) have recently been discussed. Visual artefacts have been argued to help with wicked problems (Suoheimo, 2019). Among these, a particular type known as the “Visual Inquiry Tool” has recently gained popularity for helping address this type of issue (Avdiji et al., 2020). Visual Inquiry Tools are diverse, covering a broad spectrum of applications; from supporting academic tasks like literature reviews (e.g., the Search Canvas in Schoormann et al. (2021)) to addressing corporate-oriented wicked problems, such as brand identity communication (e.g., the Identity Communication Map in Elikan and Pigneur (2019)). Instead of conventional tools that may exacerbate wicked problems by encouraging managers to produce standard ill-suited solutions (Camillus, 2008) Visual Inquiry Tools have been developed to facilitate a less linear and more creative process. Specifically, they aim to help individuals tackle wicked problems in the following ways. First, they allow one to approach uncertain situations in which there are no straightforward answers by clarifying problems through exploration and sensemaking strategies (Dalsgaard, 2017). They facilitate the formation of ideas and hypotheses about how to address problems, frame the problem with a conceptual model and create a shared visualisation (i.e., a canvas) by structuring the components logically into a visual problem space (Avdiji et al., 2020). Second, by providing a shared language and/or a shared visualisation, they support several challenges of collaboration related to sense-making, sense-giving, and action planning in multidisciplinary teams. This is particularly important as wicked problems such as climate change for example call for interdisciplinarity (Wohlgezogen et al., 2020). Doing so also calls for coordination which hinges on the ability to manage dependencies between people, tasks and resources to attain an objective (Espinosa et al., 2004). Third, Visual Inquiry Tools allow for better structuring of problems and facilitate solution searches in innovative ways (Osterwalder & Pigneur, 2011). They aim to support the process of joint inquiry (i.e., joint exploration of a problem and generation of potential solutions ideas) from cross-boundary teams with a diverse set of knowledge, set of expertise and resources (Avdiji et al., 2020). Their design has been theorised by Avdiji et al. (2020) and according to the design theory, a Visual Inquiry Tool essentially consists of a shared visualisation composed of empty building blocks alongside directions of use. The generic use case of a Visual Inquiry Tool involves users alternating between problem formulation and solution exploration by discussing each building block and subsequently placing post-it notes with their answers and thoughts in each of the corresponding sections of the Visual Inquiry Tool.

Existing Shortcomings

The design theory for Visual Inquiry Tools (Avdiji et al., 2020) is tailored towards creating paper-based Visual Inquiry Tools. However, because of its physical nature, this approach does not allow for collaboration among users who are not geographically in the same place. To address this limitation, well-known Visual Inquiry Tools such as the Business Model Canvas (Osterwalder & Pigneur, 2011) have been implemented on commercially available collaborative platforms such as Miro or Mural. Ultimately, Miro (or other similar commercially available tools such as Mural or Google Jamboard for example) is a digitisation of the post-it approach through the form of an online digital whiteboard where individuals can collaborate on a same Visual Inquiry Tool. Despite incorporating digitisation-enabled features such as distributed team collaboration, the possibility to draw/write with a digital pen or access ready-made templates (Chan et al., 2023), the Miro platform provides little for the **coordination** necessary with diverse team members (Rico et al., 2008) such as managing people-resource-task dependencies (Espinosa et al., 2004). Furthermore, while Visual Inquiry Tools implemented on online digital whiteboard platforms support solution definition, they can become difficult to use when one must write a lot of text on post-it notes as the platform limits the amount of text per post-it note. Moreover, Visual Inquiry Tools digitised on online digital whiteboards do not accommodate emergent **changes** as creating interrelations between parts of the Visual Inquiry Tool (e.g., post-it and building blocks) is not possible. Hence, if a user of a Visual Inquiry Tool digitised on Miro modifies the content on a post-it for example, the modification will not automatically be repercussed to the rest of the Visual Inquiry Tool. Consequently, tracking changes becomes more difficult because 1) they must manually be updated and 2) the interrelations need to be understood implicitly by the user, which may be particularly challenging when dealing with complex problems, especially in interdisciplinary settings where stakeholders have diverse knowledge. Finally, on platforms such as Miro, the integration of different **views** of the problem and solutions is not accommodated. A Visual Inquiry Tool digitised on Miro can only present a limited number of parts and sub-parts as one cannot zoom in on post-it to see its underlying functions or deeper relations to other post-its or zoom out to have a holistic view of the relations. This implies that there is no functionality to move from defining the problem or exploring the solution (with post-it notes) to creating content for the solution (for instance, if you have a post-it note 'conduct a market study', you will have to write the results of the market study in another document).

Given the urgency of tackling the wicked problems of our time, such as climate change (Wohlgezogen et al., 2020) through a socio-ecological transformation (Sediri et al., 2020) for example, or making organisations more adaptive through large-scale agile transformations (Roschnik & Missonier, 2024), it seems imperative to take Visual Inquiry Tools to the next level by addressing these current limitations.

Theoretical Grounding: Systems Thinking

In this study, we leverage systems thinking as theoretical grounding to address the shortcomings discussed above. Systems thinking is a learning method and paradigm (Senge, 1990) which implies understanding the web or interrelations between the elements of a system. It is a theoretically grounded and valuable perspective to view and understand the diverse representations of systems in the world (Matook & Brown, 2016) and can help address complex problems (Monat & Gannon, 2015). In other words, systems thinking is a different way of thinking about our relationship with the world (Allen et al., 2019), and about how change happens (Voulvoulis et al., 2022). A system can be understood as "*a representation of an entity as a complex whole open to feedback from its environment*" (Ryan, 2008, p. 28). Accordingly, through a systems thinking perspective, the parts of a system are interconnected and interdependent and form a whole which is more (or different) than the sum of its parts (von Bertalanffy, 1972). As illustrated by Richmond (1994), within the systems thinking paradigm, one observes both the forest and the trees that compose the forest. In addition to its structure, a system is characterised by the openness of its boundaries that separates it from its environment (Matook & Brown, 2016). The more open the boundaries, the more a change in the system's environment will impact the parts of the said system, potentially resulting in a transformation of the entire system (Ackoff, 1971). Systems can hold a multitude of shapes of varying degrees of complexity, each interacting uniquely with its environment (Matook & Brown, 2016). They can be seen as "systems of systems" with hierarchical layers that interconnect components and with complexity increasing at higher levels (Boulding, 1956). Systems respond to stimuli from the environment that may impact their balanced state (Miller, 1965), and in turn, use feedback mechanisms to facilitate their transformation and adaptation to restore a balanced state (Matook & Brown, 2016). Specifically, they exchange inputs from a sub-system or the environment for outputs that are spread to other parts of the system or to the environment. The above characteristics of a system are encapsulated in five concepts central to systems thinking derived from seminal works such as those by von Bertalanffy (1972) and Ackoff (1971) in Matook and Brown (2016). Namely, the five concepts that make up a system are: 1) parts, wholeness, and structure 2) boundary and environment, 3) hierarchical order, wholeness, and complexity, 4) state and change of state and 5) transformation and feedback. From a broader perspective, within systems thinking, both socio- and technical aspects are intertwined and evolve within a context (e.g., the enterprise) (Alter, 2004). In a systems perspective, individuals are actively engaged in the system as participants, as opposed to a tool-centric view where the focus is on the tool itself, and the individuals are merely its users rather than active participants (Alter, 2004).

Systems thinking has a longstanding presence within the IS discipline (Hirschheim, 1983; Checkland, 1988), with scholars advocating for a broader systems view in IS research as early as two decades ago (Alter, 2004) and Work System Theory having gained considerable attention the past decade (Alter, 2013). In recent years, this perspective has re-gained traction in the IS literature, where it has been used as a lens to describe characteristics of the IT artefact (Matook & Brown, 2016), contemporary phenomena such as agile transformations (e.g., Bieler, 2018) or digitalisation for sustainability endeavours (Hassan, 2023). Additionally, research on business model sustainability has adopted a systems thinking approach, emphasising the interconnectedness of business models within the enterprise and its broader context (Schlüter et al., 2023). Furthermore, according to Grewatsch et al. (2023), there has been a renewed interest in systems thinking among organisational scholars as it has been deemed valuable for viewing and addressing wicked problems. Moreover, the use of systems thinking for addressing wicked problems has also been explored in specific domains, including water resources management (Ram & Irfan, 2021) and engineering design (Wilson et al., 2024). This perspective allows one to fully consider the inherent complexity and big picture of the topic, to ultimately help understand complex real-world problems (Godfrey et al., 2010).

To integrate systems thinking we draw on Baiyere et al. (2023), who, by delving into the ontological foundations of "digital," provide a clearer understanding of digitalisation. The authors discuss that digitalisation expands beyond the technical aspect to encompass the contextual and societal implications of digitisation. It includes the potential changes that occur when digital objects are used in socio-technical contexts, where both the material representations of information (digitisation) and the social processes involved in using the digital artefact are transformed. This view sheds light on how actors can leverage the new opportunities provided by digital objects and the new connections they bring forth to achieve their goals. We, therefore, assume that by going beyond the mere conversion of an object into a digital version of it and delving deeper to modify its embedded functions, digitalisation can enable the integration of systems thinking into Visual Inquiry Tools.

Altogether, given the above, we recognise that a systems thinking approach holds the potential to help address wicked problems. However, current Visual Inquiry Tools, which are intended to help address such issues, do not inherently incorporate systems thinking concepts into their design. As a result, they either remain paper-based or are merely digitised versions on commercially available digital platforms such as Miro. On account of that, in the remainder of this study, we aim to integrate systems thinking concepts (Godfrey et al., 2010) into Visual Inquiry Tools (Avdiji et al., 2020) by developing a prototype of a Digital Inquiry Platform named co.LAB through digitalisation (Baiyere et al., 2023).

Research Approach

To meet the objective of this study, we adopt the Design Science Research paradigm (Hevner et al., 2004; Nunamaker et al., 1990). Design Science Research aims to develop a new or improved artefact to solve a real-world issue through iterative building and evaluation of the designed artefact with insights from both the environment (i.e., field) and existing knowledge base (e.g., the body of literature and different theories) (Hevner et al., 2004). In Design Science Research, the problem is identified in the "problem space", and the solution is designed and evaluated in the "solution space" (vom Brocke & Maedche, 2019).

Problem space

We carved out the problem space from the existing literature on wicked problems, Visual Inquiry Tools and systems thinking presented in the Background section of this paper and we additionally took into consideration our own experiences in both designing and using Visual Inquiry Tools (reflection-on-action, (Schön, 1983)) (e.g., Roschnik and Missonier (2023)). In the following paragraph, we describe the problem space by leveraging the conceptualisation proposed by Maedche et al. (2019) which is articulated around four components: 1) The "stakeholders" who are the people and/or an organisation involved or interested in the Design Science Research project, 2) the "needs" that are what is wanted and that can be seen as the problem that is being addressed, 3) the "goals" that are the overarching desired outcomes and finally, 4) the "requirements" that are what must be considered to meet the goal(s). We formulated the requirements following the template for natural language requirements (Rupp, 2013) and subsequently derived the requirements into design principles about both the user activity and the artefact. To this end, we formulated the design principles by using the design principle schema outlined in Gregor et al. (2020): "DP Name: For *Implementer I* to achieve or allow for *Aim A* for *User U* in *Context C*, employ *Mechanisms M1*, *M2, … Mn* involving *Enactors E1, E2, … En* because of *Rationale R".*

There are two main groups of **stakeholders** in this Design Science Research project. The first group is the Visual Inquiry Tool designers who are mainly (IS) scholars (e.g., Roschnik et al. (2024) who designed the Agile Team Canvas). The second group are the end-users of the Visual Inquiry Tool. They can be practitioners (e.g., an agile team as in Roschnik et al. (2024)) or scholars (e.g., Design Science researchers as in vom Brocke and Maedche (2019)). Both groups of stakeholders may be geographically dispersed and part of multidisciplinary teams. Their overarching **goal** is to contribute to addressing a wicked problem. Specifically, the goal of the end-users of a Visual Inquiry Tool is to work on a wicked problem for which the instantiation of the Visual Inquiry Tool they are using was designed for. Meanwhile, the goal for Visual Inquiry Tool designers is to create relevant Visual Inquiry Tools that can be used by their intended end-users. Regarding the **needs**, when designing Visual Inquiry Tools, designers need to account for knowledge and documentation transfer to ease collaboration between the multidisciplinary end-users. They additionally need to accommodate for coordination challenges that arise from geographically distributed and multidisciplinary teams. Additionally, when designing Visual Inquiry Tools, designers need to account for the different perspectives and knowledge held by the end-users and allow them to visualise the relations between the different parts. Finally, they need to develop Visual Inquiry Tools that are sustainable over time and can accommodate emergent changes, reflecting the evolving understanding of the problem and its solutions inherent when dealing with wicked problems. The **requirements** (Rupp, 2013) and derived **design principles** (Gregor et al., 2020) are outlined in Table 1 below.

Requirements (Rupp, 2013)	Design principles (Gregor et al., 2020)
When being used, the solution should allow Visual Inquiry Tool designers to foster collaboration and coordination amongst the diverse end-users of a visual inquiry	DP1: For designers (implementer) to allow for remote collaboration (aim) of geographically dispersed and multidisciplinary end-users of visual inquiry tools (users) when designing visual inquiry tools (context) - M1.1.: Ensure the solution allows stakeholders (enactor) to access the platform through an open-source web platform (mechanism) as they need to access the Visual Inquiry Tool regardless of their geographic location (rationale) - M1.2: Ensure the solution allows stakeholders (enactor) to access a collaborative workspace (mechanism) as they need to work collaboratively both synchronously and asynchronously (rationale)

tool, including those from various disciplines and with different perspectives on the problem.	DP2: For designers (implementer) to allow for coordination (aim) amongst geographically dispersed and multidisciplinary end-users (users) when designing visual inquiry tools (context) - M2.1: Ensure the solution allows stakeholders (enactors) to coordinate through coordination methods (mechanism) because stakeholders (enactors) need to coordinate as part of their multidisciplinary work (rationale) - M2.2: Ensure the solution includes the possibility to view, create and share resources (mechanism) because stakeholders (enactors) hold different knowledge (rationale)
When being used, the solution should allow visual inquiry tool designers to foster a systems thinking perspective towards the visual inquiry tool. -	DP3: To allow designers (implementer) to foster a systems thinking perspective (aim) for the end-users (users) employing a visual inquiry tool (context) - M3.1: Ensure the solution allows stakeholders (enactor) to create interconnected parts that form a whole (mechanism) - M3.2: Ensure the solution allows stakeholders (enactor) to be part of the system (open boundaries) (mechanism) - M.3.3: Ensure the solution allows stakeholders (enactor) to switch views from the visualisation of the problem to the development of the solution (or refine the visualisation of the problem) through the integration of parts, sub-parts and so on (mechanism) - M.3.4: Ensure the solution accommodates changes from external stimuli (i.e., users) through feedback loops (mechanism) because this will embody the concepts of systems thinking as defined by (Matook & Brown, 2016) (rationale)

Table 1. Requirements and Design Principles for the Digital Inquiry Platform, co.LAB

Solution Space

The artefact was **developed** from scratch by two authors on the author team that implemented it onto an open-access web-platform to support the collaborative work of the diverse stakeholders. The co.LAB platform was initially designed to support teams confronted with the specific wicked problem of serious game design (Sanchez et al., 2023) and was then extended for test usage as a generic platform for wicked problem-solving. The platform was developed based on a review of functionalities needed for collaborative problem solving, including visual representation of the problem space, collaborative work, project management, and provision of different views of the problem.

Co.LAB allows users to have an up-to-date vision of the Visual Inquiry Tool, regardless of their geographical location (M.1.1). We created a collaborative workspace with cards, allowing multiple users to collaboratively work on the wicked problem, as the platform allows users to see, edit, create, delete, copy, and cut content both synchronously and asynchronously. This feature transforms cards into collaborative workspaces, enabling linear text editing (M1.2). For coordination, we implemented a role allocation with a RACI (responsible, accountable, consulted, and informed) matrix and a visual progress tracking feature (M2.1). We additionally implemented a feature that allows stakeholders to view, create, and share resources and documentation regarding the entire Visual Inquiry Tool or a specific card (M2.2). Regarding DP3, we developed the capability for cards to contain other cards, each interrelated and organised hierarchically as parent and child cards (M3.1 and M3.3). Users are integrated as participants in the system, ensuring open boundaries (M3.2). We additionally implemented the ability to transition from problem visualisation to solution development (or refine the problem visualisation by zooming in for more detail or zooming out for a holistic view) (M3.3). Lastly, we ensured the Visual Inquiry Tool can evolve based on participant input, showing responsiveness to external stimuli (M3.4). In the artefact description section of this paper, we further present and discuss the developed features.

The artefact underwent two evaluation episodes. The **first evaluation episode** of the co.LAB platform involved 15 Master students using it in a course, after which they completed a questionnaire to assess its usability using the French version of the System Usability Scale (F-SUS) (Gronier & Baudet, 2021). The questionnaire also included five-point Likert questions and open-ended questions to evaluate the functionalities of the co.LAB platform. The questionnaire was followed by a focus group to delve deeper into student feedback. This first evaluation primarily focused on the HCI aspects of the artefact and is further detailed in Sanchez et al. (2023). Results from the questionnaire were overall rather positive (51/100 for the F-SUS scale) and new functionalities such as the possibility to add images were requested. In this paper, we present the version of the co.LAB platform after having taken into account the evaluation results. In this paper, we focus on the **second evaluation episode** conducted to assess whether co.LAB facilitates systems thinking and appropriately supports collaborative and coordination work. To this end, we followed guidance on the evaluation of IS artefacts (Prat et al., 2015) and carried out a demonstration and simulation-based benchmarking of the co.LAB platform against the systems thinking concepts (Matook & Brown, 2016) along with collaboration and coordination aspects. To do so, we employed three different formats (paper-based, on Miro and, on co.LAB) of an instantiated Visual Inquiry Tool (the Agile Team Canvas (Roschnik et al., 2024)) and conducted three workshops (Thoring et al., 2020) with a total of 15 practitioners. We further describe the data collection and analysis method along with the evaluation results in the "Artefact Evaluation" section of this paper.

Artefact Description: a Digital Inquiry Platform named co.LAB

In this section, we present the current version of the co.LAB Digital Inquiry Platform. This platform serves as a functional prototype of a collaborative open-access web platform where Visual Inquiry Tool designers can upload their Visual Inquiry Tool (and its associated directions of use (Avdiji et al., 2020)), which can then be accessed, modified and used by the end-users.

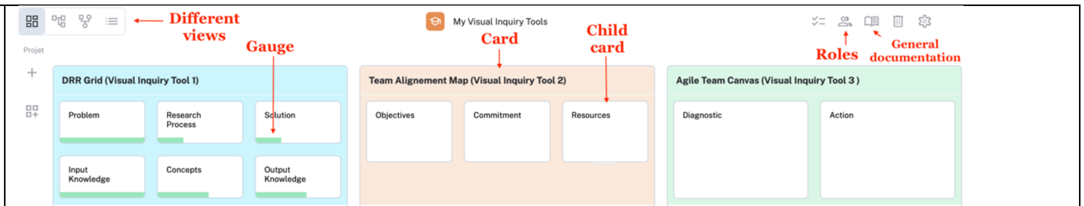
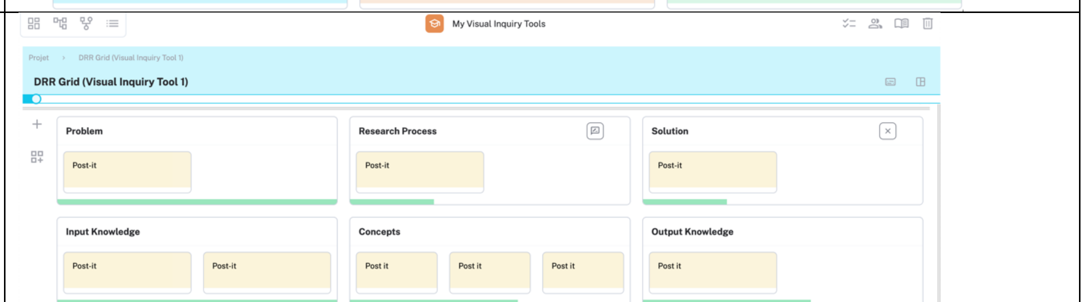
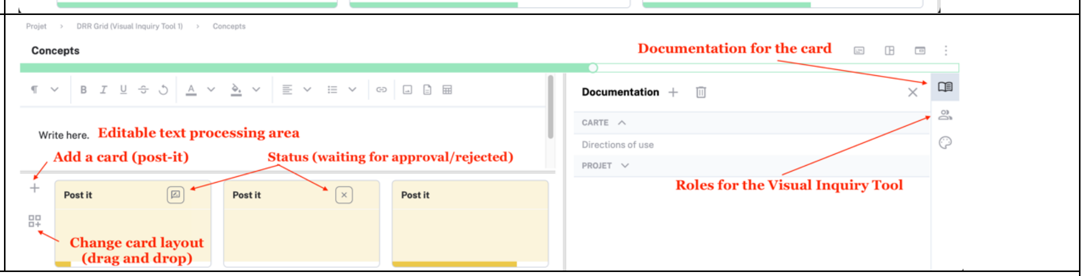
co.LAB homescreen	
co.LAB inside a Visual Inquiry Tool	
co.LAB inside a Card	

Table 2. Snapshots of co.LAB

The first snapshot in Table 2 is the **home screen** of the Digital Inquiry Platform. Co.LAB can host multiple Visual Inquiry Tools and allows each user to create their personalised workspace with various Visual Inquiry Tools relevant to them. For illustration purposes, we implemented three different Visual Inquiry Tools found in the literature: 1) the Design Science Research Grid (vom Brocke & Maedche, 2019), 2) the Team Alignment Map (Avdiji, 2018) and 3) the Agile Team Canvas (Roschnik et al., 2024). Within a Visual Inquiry Tool (second snapshot in Table 2), each building block should be implemented as a **Card** and each card can contain child cards. The cards are a collaborative workspace for each building block. Therefore, by clicking on the card, the users access a dedicated collaborative workspace (third snapshot in Table 2). The workspace of each card provides collaborative functionalities such as an editable text processing area for collaborative writing, images, and links. Each card also includes an editable **Documentation** section that includes the directions of use of the Visual Inquiry Tool (Avdiji et al., 2020) and definitions that can be linked to other cards or other external resources such as theoretical references. There are two main types of **Relationships** between cards. The first, causality, is used to inform that something defined in one card must be taken into account in another. The second, which can be called interrelationship, indicates that two cards should be seen as a coherent whole. This interrelationship can also be described as a bi-directional causality. Co.LAB further supports the systemic and dynamic view of the problem and solutions by allowing users to switch between different **Views**. This allows them to alternatively focus on elements of the problem or solutions by zooming in/out or on the relationships between those elements (hierarchical view). Each user is assigned a **Role**, such as guest, member, manager, or owner, each with varying levels of editing rights, from reader/user to card editor, depending on their selections. To fit the needs of different Visual Inquiry Tools, the list of available roles is editable for each Visual Inquiry Tool. For each card, a user can be assigned to a task (RACI matrix). Additional coordination functionalities include the **Gauge** feature to facilitate the visual tracking of progress and the **Status** feature to help track the status of each card which can range from "none" to "in progress," "validated," "rejected," or "archived."

Artefact Evaluation

We evaluated co.LAB through two different evaluation episodes as described in the “Solution Space” section of this paper. In this section, we concentrate on the second evaluation episode whose main goal was to gather whether – or not, co.LAB allows the integration of systems thinking into Visual Inquiry Tools and whether it sustains collaboration and coordination among its users. To structure and ensure rigour in the evaluation, we drew on Prat et al. (2015) who outline evaluation characteristics presented in Table 3 below.

Evaluation Setting

To evaluate the Digital Inquiry Platform, we used an instantiated Visual Inquiry Tool named the Agile Team Canvas (Roschnik et al., 2024) (selected through convenience sampling) and implemented it onto the platform. The Agile Team Canvas is a paper-based Visual Inquiry Tool designed to facilitate collaborative work on team culture by allowing team members to visually describe and co-design their current and desired cultures and formulate actions to bridge the gap between the two. The Agile Team Canvas was considered as pertinent because the nature of the problems tackled by teams using this tool - specifically, the challenge of cultivating agility in a team, has been clearly characterised as a wicked problem (Roschnik & Missonier, 2024). However, it is worth noting that in this study, we are not interested in the content of the Agile Team Canvas. Its application solely serves to demonstrate, test, and evaluate the Digital Inquiry Platform. Thus, the actual content of the Agile Team Canvas is not of interest in this paper as it is not the evaluand in this study (i.e., object of evaluation (Prat et al., 2015)). We therefore conducted a demonstration and simulation-based benchmarking of artefacts (Prat et al., 2015) using three formats of the Agile Team Canvas as follows: In **Format A** we used a paper-based version of the Agile Team Canvas (i.e., the original version as described in Roschnik et al. (2024). In **Format B** we used a digitised version of the Agile Team Canvas implemented on Miro.com and in **Format C** we used a digitalised version of the Agile Team Canvas implemented on the co.LAB platform.

Our interest during this evaluation was the performance of co.LAB (i.e., performance validation (Papamichail & French, 2005)) in regards to how well it integrates systems thinking, collaboration and coordination. To meet our evaluation objective, we compared the three formats (A-C) in regard to the integration of systems thinking (Matook & Brown, 2016) and each format’s ability to sustain collaboration and coordination amongst participants. To this end, we organised three workshops as outlined in Thoring et al. (2020), one per format to assess how each organically played out. There were a total of 15 participants, all of whom were practitioners from diverse industries ranging from a competence centre for sustainability (Format A), a food and beverages company (Format B) and an audio-acoustics company (Format C). We selected them because they were working in teams composed of diverse sets of skills and knowledge. To limit priming and anchoring biases, we used three different pools of participants, one for each format. This ensured that participants came in with a clean slate without previous knowledge of the Agile Team Canvas and hence, their utilisation of the Visual Inquiry Tool was not influenced by their prior knowledge or preconceptions about the Agile Team Canvas. In each workshop, participants were asked to use the Agile Team Canvas as per its initial directions of use as described in Roschnik et al. (2024). Due to the nature of each format (physical or digital), the workshops were held in different contexts (collocated or distributed).

Accordingly, during the workshop for Format A, a team of five practitioners (researchers, urbanist, and environmental engineers) from the competence centre for sustainability convened in a collocated setting, where they stook the paper version of the Agile Team Canvas on a wall and worked on it using physical post-it notes. Their session lasted 120 minutes. The workshop for Format B included a team of five practitioners (software engineers, IT architect and engineering manager) from the food and beverage company. The participants used the implemented Agile Team Canvas on Miro and employed digital post-its to work on it. Their session lasted 60 minutes. Finally, in the workshop for Format C, the last set of practitioners from the audio-acoustics company (CEO and different engineers) used the Agile Team Canvas implemented on the co.LAB platform. They worked on it asynchronously using the functionalities embedded in the platform. The engagement with the Visual Inquiry Tool was a total of 45 minutes.

Evaluation characteristics (Prat et al., 2015)	Evaluation
Evaluation criteria	The five systems thinking concepts outlined in Matook and Brown (2016): 1) parts, wholeness, and structure, 2) boundary and environment, 3) hierarchical order, wholeness, and complexity, 4) state and change of state and 5) transformation and feedback. Ability to collaborate and coordinate.
Evaluation method	Demonstration and simulation-based benchmarking of artefacts.
Evaluation technique	Simulation and descriptive
Form of evaluation	Qualitative (analysis and logical reasoning)
Secondary participants (yes or no)	Yes: 15 practitioners
Level of evaluation (abstract artefact or instantiated artefact)	Instantiated artefact: real example using an instantiated Visual Inquiry Tool named the Agile Team Canvas (Roschnik et al., 2024).
Relativeness of evaluation (absolute or comparison)	Relative to comparable artefacts: comparison of three formats of Visual Inquiry Tools: Format A, paper-based; Format B, on Miro; Format B, on co.LAB.

Table 3. Evaluation Overview

Data Collection and Analysis

Referring to the Goal-Method Framework for workshops described in Thoring et al. (2020), we collected data regarding the introduced artefact (instantiated Visual Inquiry Tool), people's behaviours, opinions and interactions between each other and with the introduced artefact and the workshop's outcome. Hence, in each workshop, both the process and the outcome (completed Agile Team Canvas) were of interest to us. As per the Goal-Method Framework Thoring et al. (2020), the data was collected through various methods by two authors on the research team. These methods included observation as participant (Gold, 1958) (Format A and C), note-taking (Formats A, B and C), video recording (Format B), photography (Formats A, B and C), group discussion (Formats A and B) and interviews (Format C). The group discussions and interviews aimed to capture participants' general thoughts and remarks towards the Format they had just tested. While the collected data would later serve to compare the integration of systems thinking in each format and the collaboration and coordination enabled by each format, during the data collection we did not orient participants towards the pre-defined themes, nor did we ask direct questions in that regard.

With the collected data we performed deductive thematic analysis (Fereday & Muir-Cochrane, 2006) using the five concepts of systems thinking (Matook & Brown, 2016), collaboration and coordination as our *a priori* defined themes. As suggested by Krueger et al. (2002), we focused on the extensiveness of the feedback (i.e., if a comment was made many times by different people) rather than on its frequency (i.e., the number of times a comment was made). This decision was influenced by their assertion that a particular comment could be repeated many times by the same individual and, thus, might not accurately reflect its importance. Accordingly, we engaged in one round of coding and manually extracted the most extensive feedback and observations from the notes and recordings. We analysed how each format of Visual Inquiry

Tool unfolded, assessing what it allowed participants to do – or not – regarding the pre-defined themes. We additionally conducted artefact analysis (Thoring et al., 2020) by examining the produced artefacts (i.e., the completed Visual Inquiry Tools and their traces of use) to ascertain their alignment with the concepts of systems thinking. To mitigate subjective bias, during the process, we presented and discussed the findings with the author team. Finally, we kept in touch with participants post-workshop to resolve any potential ambiguities encountered during data analysis, seeking clarification via email or meetings when needed.

Findings: Evaluation Results

In this section, we present the findings from the three workshops we conducted to assess the different formats of Visual Inquiry Tools in regard to the concepts of systems thinking outlined by Matook and Brown (2016) as well as the collaboration and coordination enabled by each. Figure 1 below presents the photos illustrating the three instantiations post-workshop, which served as the basis for the artefact analysis (Thoring et al., 2020).

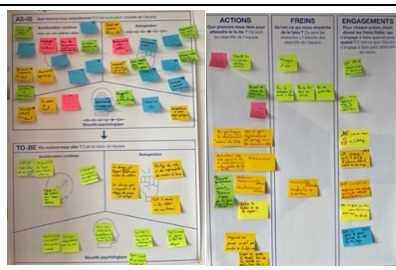


Photo A: paper-based Agile Team Canvas (Format A)

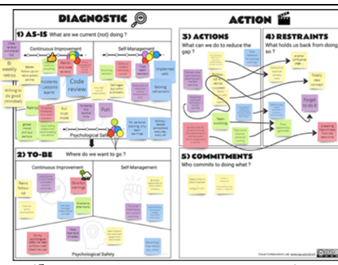


Photo B: Agile Team Canvas on Miro (Format B)

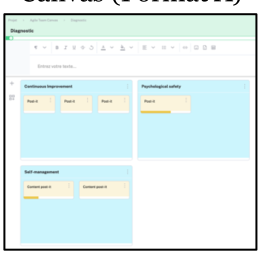


Photo C1: Agile Team Canvas on co.LAB (Format C)

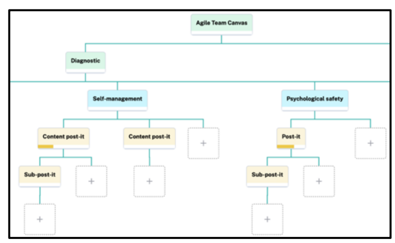


Photo C2: Snippet of hierarchical view of relations (Format C)

Figure 1. Artefact documentation

The **first concept** of systems thinking relates to the **interconnectedness** of parts that form a unified whole with inherent structure (Matook & Brown, 2016). This interconnectedness implies that each part influences and depends on others, illustrating interdependence. Regarding Format A, during the group discussion following the workshop, participants told us that they had implicitly linked the post-its together by aligning them on the same line as we can see on the right hand of the canvas in Photo A (Figure 1). In a more explicit way, participants in Format B used lines on Miro to indicate the connections between the sub-parts (post-its) (Photo B). Finally, we found that Format C offered a more detailed representation of interconnection as participants switched between views of the Visual Inquiry Tool on co.LAB allowing them to grasp the complete structure and the interdependencies between each sub-part. We can see this in Photo C2 (Figure 1). The **second concept**, **system boundary and environment**, relates to how systems are set apart from their environment (Matook & Brown, 2016). Ultimately, this boundary helps identify what is part of the system, and what is not. In Format A, the paper-based nature of the Visual Inquiry Tool established a tangible and physical boundary, distinctly separating it from the external environment. In Formats B and C, where the Visual Inquiry Tools were implemented within larger digital systems (Miro or co.LAB), the boundaries were conceptual rather than physical, as depicted in Photos B and C1. Regarding participants' engagement with the Visual Inquiry Tool, we observed across all workshops that participants contributed to the system, as described by Alter (2004), by imparting their knowledge through discussions and post-its. This interactive involvement implies a degree of boundary openness; if boundaries were entirely closed, participant inputs would not have influenced the Visual Inquiry Tool. This showcases the socio-technical aspect induced by Formats B and C as the digital artefacts (instantiations of the Visual Inquiry Tool on Miro and co.LAB) evolved within a socio-context. Format A however does not include the technical aspect because of its paper-based nature. The **third concept**, **hierarchical order, wholeness, and complexity,** describes how systems are structured hierarchically based on the complexity of their subsystems and interdependent components (Matook & Brown, 2016). Systems are often viewed as “systems of systems”, interconnected through hierarchical parts that capture their relationships and dependencies (von Bertalanffy, 1972). In both Formats A and B, we can observe by looking at their respective photos in Table 1, that participants only exhibited a single-level depth in their answers as they wrote post-its in each section of the Visual Inquiry Tool but did not go deeper by further nesting their answers. On the other hand, in Photo C.2 we can notice that participants were able to demonstrate a deeper hierarchical structure by incorporating post-its within post-its, implying increased complexity and interconnectivity among their responses. The limited hierarchical order in Formats A and B was pointed out by workshop participants. For instance, the engineering manager in workshop B expressed a need for prioritisation of actions (included on the post-its), as all post-its were placed on the same level. Therefore, while users visually connected the parts with drawn lines on the Visual Inquiry Tools as in Format B, or did so implicitly as in Format A, they did/could not establish a deeper hierarchical structure. Thus, in these two formats of Visual Inquiry Tools, we cannot argue that, at this level of abstraction, there is a “system of a system” structure. In Format C however, users created parts, sub-parts, sub-sub-parts and so on therefore allowing for a deeper hierarchical structure and intensified interconnectedness among all elements. Therefore, with Format C, each component can be perceived as a smaller system within a larger system, regardless of the level of abstraction. The **fourth concept** is **system state and change of state** suggests that systems possess a state and can transition between states in response to external stimuli. Once triggered, the system uses a feedback mechanism to return to a state of equilibrium (Matook & Brown, 2016). In this context, we view an equilibrium as being a state of coherence and stability among the contents of the Visual Inquiry Tool, where the post-it notes reflect a cohesive representation of the system. Attaining an equilibrium also means that the contents of the Visual Inquiry Tool accurately reflect participants’ perspectives. In Formats A and B, altering the state of one part (such as modifying, deleting, or adding a post-it note) did not directly affect the other parts within the Visual Inquiry Tool itself. In Format C, modifying, deleting, or adding a post-it note automatically altered the interrelationships and elements associated with the post-it in question (e.g., task assignment, gauge). This implies a return towards an equilibrium. From a slightly different perspective, during the three workshops, we observed that the discussed changes provoked a shift in participants’ reflections as it brought in new information for the team to consider which in turn prompted adjustments to the contents of the Visual Inquiry Tool. From this perspective, we can somewhat argue that all three formats can indeed change state in response to stimuli considering participants participate in the system as discussed in the second concept. The **fifth concept** refers to the **process by which systems exchange inputs** such as information between the system's components and its environment for outputs through various forms of feedback mechanisms, enabling them to transform (Matook & Brown, 2016). Participants in all three Formats contributed information using post-its. However, Format C stands out for its automatic repercussion of inputs across the Visual Inquiry Tool, in particular regarding **coordination** activities. Indeed, with Format C participants could assign tasks and edit their status directly in the Visual Inquiry Tool (which allows for a transformation of the Visual Inquiry Tool when a task has been marked as completed for example). However, during the group discussions participants from workshops A and B mentioned that they could foresee documenting and tracking workshop outcomes (e.g., action points) for the long run as an issue as further coordination efforts would be required outside the Visual Inquiry Tools (Format A and B). When, as a follow-up question, we asked participants how they were going to do so, the researcher from workshop A told us that they were going to report each point on an Excel sheet as a workaround. Consequently, the transformation of the Visual Inquiry Tool in Formats A and B does not perpetuate as they are not used in the longer run and they lack an embedded feedback mechanism within the Visual Inquiry Tool. Finally, regarding the **collaborative** features across the three formats, in Format A we observed that the interactions among participants (Thoring et al., 2020) were richer and longer as their conversations went into depth about each topic. This is likely due to its collocated nature facilitating easier communication. This resulted in an extended duration of Agile Team Canvas utilisation (120 minutes) as opposed to the other two workshops which were shorter. However, Format A is less practical for dispersed participants whereas both Format B and C are suitable for geographically distributed teams, offering collaborative functionalities. In Format C, each card provides access to a dedicated collaborative workspace, enabling both synchronous and asynchronous document collaboration. Similarly, in Format B, collaboration is facilitated through digital whiteboard features, with the ability to add post-it notes directly onto the Visual Inquiry Tool. We discuss the implications of these findings in the subsequent section.

Discussion

Today's landscape is shaped by complex "wicked" problems (Rittel & Weber, 1973), such as social-ecological transformations (Sediri et al., 2020). Visual Inquiry Tools have recently been theorised as a tool to help address these challenges (Avdiji et al., 2020). We however find that they are currently limited in their ability to accommodate the novel and changing knowledge regarding both the problem definition and resolution, the multiple perspectives held by the diverse stakeholders along with their (remote) collaboration and coordination. All of which are central to wicked problems. In this study, we address this shortcoming by drawing on systems thinking (Matook & Brown, 2016) and digitalisation Baiyere et al. (2023) to design, implement and evaluate, within the Design Science Research paradigm (Hevner et al., 2004; Nunamaker et al., 1990), a prototype of a Digital Inquiry Platform named co.LAB.

Contributions and Implications

This study bears noteworthy implications and contributions to both academia and practice as follows. First, as Design Science Research aims to design innovative artefacts to address real-world issues, it is essential that these artefacts achieve relevance (Hevner et al., 2004). In that regard, as witnessed with instantiations like the Agile Team Canvas (Roschnik et al., 2024) (in Figure 1) or the Design Science Research Grid (vom Brocke & Maedche, 2019) (in Table 2), our designed artefact - co.LAB - is capable of hosting multiple and different instantiations of Visual Inquiry Tools, both existing and those that have yet to be designed. Co.LAB provides common elements found in most Visual Inquiry Tools (e.g., building blocks and directions of use (Avdiji et al., 2020)) while remaining adaptable to accommodate the unique characteristics of different instances. With contributions towards these tools on the rise (vom Brocke & Maedche, 2019) and the persistent prevalence of wicked problems, co.LAB offers a promising avenue for collaborative problem-solving in distributed environments. Looking ahead, co.LAB's potential for facilitating interdisciplinary research positions it as particularly promising for addressing, amongst others, wicked problems related to sustainability (Wohlgezogen et al., 2020). Finally, its open-source feature enhances accessibility and inclusivity, allowing both academics and practitioners to engage in either the design or use of Visual Inquiry Tools. This aligns with the call for openness and accessibility within the field, particularly in Design Science Research (Doyle et al., 2019). We consequently encourage IS design researchers to consider implementing their Visual Inquiry Tool on the co.LAB platform, to enhance the accessibility of their tools. Moreover, as more Visual Inquiry Tools are implemented, used, and evaluated on co.LAB, the platform itself will undergo further validation, thereby strengthening its contribution to the fields of visual inquiry and wicked problems.

Second, in this research, we integrated systems thinking through digitalisation (Baiyere et al., 2023). Instead of digitising the Visual Inquiry Tool on a commercially available tool (e.g., Miro), where the core of the Visual Inquiry Tool remains the same (i.e., the functions of the Visual Inquiry Tool remain the same but in a digital format), we went beyond digitisation to integrate new ways of interacting with and viewing the Visual Inquiry Tool (e.g., interrelationships, different views, roles). Doing so speaks to the socio-technical context of the Visual Inquiry Tool where not only is a digital version proposed, but it opens up for new and different ways of working with Visual Inquiry Tools. By doing so, we link the established literature on systems thinking to the growing one on Visual Inquiry Tools through digitalisation to propose a novel artefact embedding systems thinking. We must however warn that, from our findings, we realise that the aim is not to digitalise - nor even digitise - just for the sake of it. We indeed found that collaboration, in terms of interactions amongst the users of the Visual Inquiry Tool, was more sustained in the paper-based format (Format A) compared to the other two. That being said, our evaluations indicated that the coordination activities such as documenting knowledge or tracking workshop outcomes were better sustained by the Visual Inquiry Tool implemented on co.LAB (Format C). Thus, while the digital aspect of the Visual Inquiry Tool allows for a better follow-up, collaboration is better sustained when users are physically together and use a paper-based Visual Inquiry Tool. Consequently, each format of Visual Inquiry

Tool bears its own merits depending on the situational factors of the stakeholders, and we find that compromises are necessary between addressing problems that call for collaboration of various stakeholders with diverse knowledge whilst not being collocated. This trade-off highlights the need for effective collaboration with the practicalities of coordination in different formats. Future research could further investigate the strengths and weaknesses of each format to better understand these dynamics and provide more nuanced recommendations.

Third, twenty years ago, Alter (2004, p. 758) wrote "*Everyone in the IS field does a lot of thinking about systems, but one might wonder whether thinking about systems necessarily involves systems thinking*" as he then called for further research involving systems thinking in IS. Two decades later, this call is still echoed by researchers (Hassan, 2023) indicating that the tool perspective (Alter, 2013) remains predominant. In this study, we steer away from the tool perspective of Visual Inquiry *Tools* to examine them as systems. Drawing inspiration from neighbouring disciplines (e.g., Grewatsch et al., 2023), we propose that systems thinking could offer valuable insights into addressing wicked problems. Consequently, we argue that artefacts aimed at helping address wicked problems (i.e., Visual Inquiry Tools) could benefit from being designed under the lens of systems thinking. In line with this, we have developed co.LAB, a platform capable of hosting Visual Inquiry Tools. Co.LAB not only introduces a systems thinking perspective but also increases both synchronous and asynchronous collaboration and coordination among geographically dispersed stakeholders. However, it is worth noting that, due to their wicked nature, wicked problems are not solved as such (Alford & Head, 2017). Rather they are resolved over and over (Rittel & Weber, 1973). Therefore, while we do not claim that co.LAB solves wicked problems entirely, we do argue that, based on our evaluations, co.LAB facilitates the integration of diverse perspectives from various and geographically dispersed stakeholders. It additionally helps accommodate both synchronous and asynchronous changes in the understanding of the problem and the formulation of solutions and allows for both a holistic and detailed view of the parts and their interrelationships. This makes co.LAB a valuable platform for navigating the multifaceted challenges associated with wicked problems, particularly in areas where the interplay of various elements and geographically dispersed stakeholder perspectives is crucial. Altogether, co.LAB allows Visual Inquiry Tools to be viewed through the systems thinking lens rather than solely as tools (Alter, 2013), thereby bridging two bodies of literature (i.e., systems thinking and Visual Inquiry) and contributing to helping IS research address wicked problems. However, although in this study our focus has been directed towards digitalisation (Baiyere et al., 2023), we believe that there are yet unexplored paths for incorporating systems thinking into Visual Inquiry Tools. Future research could explore these paths to deepen our understanding and broaden the scope of these artefacts.

Fourth, in this study, we have proposed a set of design principles formalised according to Gregor et al. (2020). By leveraging the concepts of systems from Matook and Brown (2016) to inform the formulation of the design principles for the Digital Inquiry Platform, we ensured our design principles were firmly rooted in the established literature. Furthermore, by instantiating the design principles into the co.LAB platform and performing a comparative benchmarking with other formats of Visual Inquiry Tools, we have evaluated the formulated design principles. We therefore contribute to the prescriptive knowledge of integrating systems thinking, collaboration, and coordination into Visual Inquiry Tools. Moreover, these design principles serve as a nascent design theory in IS (Gregor and Hevner, 2013) and can be further instantiated. Finally, additional instantiations and testing of these design principles across different contexts would help evaluate their projectability (i.e., a design science alternative to generalisability (Baskerville & Pries-Heje, 2014)).

Limitations

While our study provides valuable insights into the integration of systems thinking into Visual Inquiry Tools, we must acknowledge the limitations of this study. Accordingly, the main limitation concerns the evaluation of the co.LAB platform, conducted in three distinct settings with three participant pools and data collection methods. In doing so, we aimed to assess how each format of Visual Inquiry Tool (i.e., Format A, B and C) organically unfolded in terms of systems thinking, collaboration, and coordination. However, to avoid priming and anchoring biases, we used separate participant pools, potentially limiting the comparability of results. Future research could address this limitation by evaluating the three formats of Visual Inquiry Tools employing the same team across all formats for a more robust comparative analysis. Furthermore, additional data (e.g., comparative case study) is necessary to further establish the value that co.LAB brings to addressing wicked problems. Moreover, as our study primarily focused on integrating systems thinking, we concentrated on this aspect during the evaluation. Future investigations could evaluate Visual Inquiry Tools implemented on co.LAB against the five evaluation criteria proposed by the design theory for Visual Inquiry Tools (Avdiji et al., 2020). Namely, its efficacy, effectiveness, efficiency, elegance, and ethicality. Further research could also evaluate the overall utility of LAB by using evaluation criteria, such as relevance, completeness, formal and volume of output, ease of use and learning as outlined in Papamichail and French (2005). Finally, it is worth mentioning that, although implemented and usable, co.LAB is still in the prototype stage. It therefore needs further refinement and development to enhance its functionalities. Despite not having been explicitly commented upon, we believe that the prototype look and feel of co.LAB could have influenced participant perceptions in this regard. These limitations highlight the need for continued refinement of the Digital Inquiry Platform in future studies to overcome the limitations and fully leverage the potential of Visual Inquiry Tools in addressing wicked problems.

Conclusion

Our objective in this study was to examine how Visual Inquiry Tools could further account for the complex characteristics of wicked problems while enabling remote collaboration and coordination among diverse stakeholders. To meet our objective, we conducted a Design Science Research study, leveraging systems thinking as theoretical grounding and drawing on empirical data to evaluate the designed artefact. The designed artefact is an open-access collaborative Digital Inquiry Platform named co.LAB capable of hosting different instances of Visual Inquiry Tools, thereby contributing to the emerging field of Visual Inquiry Tools. Co.LAB can be used by both IS design scholars and practitioners in their respective works. Overall, this research contributes to advancing our understanding of how Visual Inquiry Tools can be enhanced to help tackle wicked problems prevalent as part of today's increasingly complex world (Benbya et al., 2020).

References

Ackoff, R. L. (1971). Towards a System of Systems Concepts. *Management Science*, *17*(11), 661-671.

Alford, J., & Head, B. W. (2017). Wicked and less wicked problems: a typology and a contingency framework. *Policy and Society*, *36*(3), 397-413.

Allen, S., Cunliffe, A. L., & Easterby-Smith, M. (2019). Understanding Sustainability Through the Lens of Ecocentric Radical-Reflexivity: Implications for Management Education. *Journal of Business Ethics*, *154*(3), 781-795.

Alter, S. (2004). Desperately Seeking Systems Thinking in the Information Systems Discipline. In *Proceedings of the Twenty-Fifth International Conference on Information Systems (ICIS)*. 757-770.

Alter, S. (2013). Work System Theory: Overview of Core Concepts, Extensions, and Challenges for the Future. *Journal of the Association for Information Systems*, *14*(2), 72-121.

Avdiji, H. (2018). Supporting the challenges of cross-boundary teamwork through design science research. [PhD Thesis, University of Lausanne]. Switzerland.

Avdiji, H., Elikan, D., Missonier, S., & Pigneur, Y. (2020). A Design Theory for Visual Inquiry Tools. *Journal of the Association for Information Systems*, *21*(3), 695-734.

Baiyere, A., Grover, V., Lyytinen, K. J., Woerner, S., & Gupta, A. (2023). Digital "x"—Charting a Path for Digital-Themed Research. *Information Systems Research*, *34*(2), 463-486.

Baskerville, R., & Pries-Heje, J. (2014). Design Theory Projectability. In B. Doolin, E. Lamprou, N. Mitev, & L. McLeod (Eds.), *IFIP Advances in Information and Communication Technology*. (pp.219-232). Springer, Berlin.

Benbya, H., Nan, N., Tanriverdi, H., & Yoo, Y. (2020). Complexity and Information Systems Research in the Emerging Digital Word. *MIS Quarterly*, *44*(1), 1-17.

Bieler, E. A. (2018). Analyzing the United States Air Force agile transformation using a systems thinking approach. [Graduate Thesis, Massachusetts Institute of Technology (MIT)].

Boulding, K. (1956). General Systems Theory: the Skeleton of Science. *Management Science*, *2*(3), 197-208.

Buchanan, R. (1992). Wicked Problems in Design Thinking. *Design Issues*, *8*(2), 5-21.

Camillus, J. C. (2008). Strategy as a Wicked Problem. *Harvard Business Review*, *86*(5), 99-106.

Chan, T. A. C. H., Ho, J. M., & Tom, M. (2023). Miro: Promoting Collaboration through Online Whiteboard Interaction. *RELC Journal*, 1-5.

Checkland, P. B. (1988). Information Systems and Systems Thinking: Time to Unite. *International Journal of Information Management*, *8*(4), 239-248.

Dalsgaard. (2017). Instruments of Inquiry: Understanding the Nature and Role of Tools in Design. *International Journal of Design*, *11*(1), 21-33.

Demetis, D. S., & Lee, A. S. (2016). Crafting theory to satisfy the requirements of systems science. *Information and Organization*, *26*(4), 116-126.

Doyle, C., Luczak-Roesch, M., & Mittal, A. (2019). We need the open artefact: Design Science as a pathway to Open Science in Information Systems research. In B. Tulu, S. Djamasbi, & G. Leroy (Eds.), *International Conference on Design Science Research in Information Systems and Technology (DESRIST)*. (pp.46-60). Springer, Cham.

Elikan, D., & Pigneur, Y. (2019). A visual tool for identity communication strategy. *Journal of Small Business and Enterprise Development*, *26*(6/7), 831-854.

Espinosa, J. A., Lerch, F. J., & Kraut, R. E. (2004). Explicit versus implicit coordination mechanisms and task dependencies: One size does not fit all. In E. Salas & S. Fiore (Eds.), *Team cognition: Understanding the factors that drive process and performance*. (pp.107-129). American Psychological Association.

Fatima, S., Desouza, K. C., Buck, C., & Fielt, E. (2022). Public AI canvas for AI-enabled public value: A design science approach. *Government Information Quarterly*, *39*(4), 1-16.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, *5*(1), 80-92.

Godfrey, P., Agarwal, J., & Dias, P. (2010). Systems 2030 – Emergent themes. *Civil Engineering and Environmental Systems*, *27*(3), 177-187.

Gold, R. L. (1958). Roles in Sociological Field Observations. *Social Forces*, *36*(3), 217-223.

Gregor, S., Kruse, L., & Seidel, S. (2020). Research Perspectives: The Anatomy of a Design Principle. *Journal of the Association for Information Systems*, *21*(6), 1622-1652.

Grewatsch, S., Kennedy, S., & Bansal, P. (2023). Tackling wicked problems in strategic management with systems thinking. *Strategic Organization*, *21*(3), 721-732.

Gronier, G., & Baudet, A. (2021). Psychometric Evaluation of the F-SUS: Creation and Validation of the French Version of the System Usability Scale. *International Journal of Human–Computer Interaction*, *37*(16), 1571-1582.

Haj-Bolouri, A. (2021). Wickedness in Designing IT for Integration Work. A phenomenological account. *Scandinavian Journal of Information Systems*, *33*(1), 261-304.

Harsaae, M. P., Nielsen, M. S., Østergaard, T., & Bang, A. L. (2023). Reorienting Design Thinking Through Systems Thinking. In *25th International Conference on Engineering and Product Design Education*.

Hassan, N. R. (2023). Bridging digitalization to sustainable futures by going back to the "systems" paradigm in information systems. In *Proceedings of the Twenty-ninth Americas Conference on Information Systems (AMCIS)*. 1-10.

Hawryszkiewycz, I. T. (2014). Visualisations for Addressing Wicked Problems Using Design Thinking. In *Proceedings of the Twenty-second European Conference on Information Systems (ECIS)*. 1-12.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75-105.

Hirschheim, R. (1983). Systems in O.R: Reflections and Analysis. *Journal of the Operational Research Society*, *34*(8), 813-818.

Krueger, R. A., Casey, M. A., Donner, J., Kirsch, S., & Maack, J. N. (2002). Designing and Conducting Focus Group Interviews. In *Social Development Papers* (Vol. 18). Social Development Department, The World Bank.

Maedche, A., Gregor, S., Morana, S., & Feine, J. (2019). Conceptualization of the Problem Space in Design Science Research. In B. Tulu, S. Djamasbi, & G. Leroy (Eds.), *Extending the Boundaries of Design Science Theory and Practice, DESRIST 19*. (pp.18-31). Springer, Cham.

Matook, S., & Brown, S. A. (2016). Characteristics of IT artifacts: a systems thinking-based framework for delineating and theorizing IT artifacts. *Information Systems Journal*, *27*(3), 309-346.

Miller, J. (1965). Living Systems: Basic Concepts. *Behavioral Science*, *10*(3), 193-237.

Monat, J. P., & Gannon, T. F. (2015). What is Systems Thinking? A Review of Selected Literature Plus Recommendations. *American Journal of Systems Science*, *4*(1), 11-26.

Nunamaker, J. F., Chen, M., & Purdin, T. D. M. (1990). Systems Development in Information Systems Research. *Journal of Management Information Systems*, *7*(3), 89-106.

Osterwalder, A., & Pigneur, Y. (2011). *Business Model Generation: a Handbook for Visionaries, Game Changers, and Challengers*. John Wiley & Sons.
Papamichail, K. N., & French, S. (2005). Design and evaluation of an intelligent decision support system for nuclear emergencies. *Decision Support Systems*, *41*(1), 84-111.
Prat, N., Comyn-Wattiau, I., & Akoka, J. (2015). A Taxonomy of Evaluation Methods for Information Systems Artifacts. *Journal of Management Information Systems*, *32*(3), 229-267.
Ram, S. A., & Irfan, Z. B. (2021). Application of System Thinking Causal Loop Modelling in understanding water Crisis in India: A case for sustainable Integrated Water resources management across sectors. *HydroResearch*, *4*, 1-10.
Richmond, B. (1994). System Dynamics/Systems Thinking: Let's Just Get On With It. *International Systems Dynamics Conference*, *10*(2-3), 135-157.
Rico, R., Sánchez-Manzanares, M., Gil, F., & Gibson, C. (2008). Team Implicit Coordination Processes: A Team Knowledge-Based Approach. *Academy of Management Review*, *33*(1), 163-184.
Rittel, H., & Weber, M. (1973). Dilemmas in a General Theory of Planning *Policy Sciences*, *4*(2), 155-169.
Roschnik, A., & Missonier, S. (2023). Co-Designing a Visual Inquiry Tool. In A. Gerber & R. Baskerville (Eds.), *Design Science Research for a New Society: Society 5.0. DESRIST 23*. (pp.430-444).
Roschnik, A., & Missonier, S. (2024). Conceptualising Scaling Agile as a Wicked Problem. In *Proceedings of the Thirty-Second European Conference of Information Systems (ECIS)*. 6.
Roschnik, A., Missonier, S., & Elbanna, A. (2024). Emerging Next Generation Technology and the Challenge of Expanding Agility Across the Enterprise: An Engaged Scholarship Approach. In S.K. Sharma, Y. Dwivedi, B. Metri, B. Lal, & A. Elbanna (Eds.), *IFIP Advances in Information and Communication Technology*. (pp.105-118). Springer, Cham.
Rupp, C. (2013). *Systemanalyse Kompakt*. Springer-Verlag.
Ryan, A. (2008). What is a Systems Approach? *Nonlinear Sciences - Adaptation and Self-Organizing Systems*, *8*(9), 1-39.
Sanchez, E., Prior, E., Mandran, N., Monnier, S., Huguenin, A., Laurent, M., Jaouadi, M., & Jaccard, D. (2023). Co.LAB, une plateforme d'accompagnement pour la conception et l'évaluation collaboratives de jeux destinés à un usage éducatif. In *Environnements Informatiques pour l'Apprentissage Humain*.
Schlüter, L., Kørnøv, L., Mortensen, L., Løkke, S., Storrs, K., Lyhne, I., & Nors, B. (2023). Sustainable business model innovation: Design guidelines for integrating systems thinking principles in tools for early-stage sustainability assessment. *Journal of Cleaner Production*, *387*, 1-14.
Schön, D. (1983). *The reflective practitioner: How professionals think in action*. Routledge.
Schoormann, T., Behrens, D., Fellmann, M., & Knackstedt, R. (2021). On Your Mark, Ready, Search: A Framework for Structuring Literature Search Strategies in Information Systems. In F. Ahlemann, R. Schütte, & S. Stieglitz (Eds.), *Innovation Through Information Systems, WI*. (pp.558-575). Springer, Cham.
Sediri, S., Trommetter, M., Frascaria-Lacoste, N., & Fernandez-Manjarrés, J. (2020). Transformability as a Wicked Problem: A Cautionary Tale? *Sustainability*, *12*(15), 1-19.
Senge, P. M. (1990). *The Fifth Discipline: the Art and Practice of the Learning Organization*. John-Wiley.
Suoheimo, M. (2019). Strategies and Visual Tools to Resolve Wicked Problems. *The International Journal of Design Management and Professional Practice*, *13*(2), 25-41.
Thoring, K., Mueller, R. M., & Badke-Schaub, P. (2020). Workshops as a Research Method: Guidelines for Designing and Evaluating Artifacts Through Workshops. In *Proceedings of the 53rd Hawaii International Conference on System Sciences*. 5036-5045.
vom Brocke, J., & Maedche, A. (2019). The DSR grid: six core dimensions for effectively planning and communicating design science research projects. *Electronic Markets*, *29*(3), 379-385.
von Bertalanffy, L. (1972). The History and Status of General Systems Theory. *Academy of Management Journal*, *15*(4), 407-426.
Voulvoulis, N., Giakoumis, T., Hunt, C., Kioupi, V., Petrou, N., Souliotis, I., Vaghela, C., & binti Wan Rosely, W. I. H. (2022). Systems thinking as a paradigm shift for sustainability transformation. *Global Environmental Change*, *75*.
Wilson, E., Dunne, D., Bergen, T., & Mukhopadhyaya, P. (2024). Reframing engineering design: Integrating design thinking and systems thinking in engineering education and practice to address wicked problems. *Canadian Journal of Civil Engineering*.
Wohlgezogen, F., McCabe, A., Osegowitsch, T., & Mol, J. (2020). The wicked problem of climate change and interdisciplinary research: Tracking management scholarship's contribution. *Journal of Management & Organization*, *26*(6), 1048-1072.