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Exploring Design Principles and Design Features to Enhance Visual Inquiry Tools for Designing Multi-Actor Ecosystems

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Abstract

Digital technologies have enabled organizations to transcend their boundaries and create joint customer value with partners, which has led to the emergence of multi-actor ecosystems. However, these ecosystems are difficult to design and develop because they are characterized by cross-industry collaborations and non-contractual mechanisms. In this context, visual inquiry tools (e.g., canvases) hold great promise for jointly exploring ecosystem opportunities and improving cooperation between ecosystem partners.

Nevertheless, the current tool landscape remains opaque, and research lacks prescriptive design knowledge regarding functions that could prevent collaboration failure and how these functions could be implemented. This paper presents the results of an observational design science research project that identifies and analyzes nine existing visual inquiry tools. It then develops and evaluates key design knowledge in the form of six design principles and sixteen design features to mitigate collaboration challenges among ecosystem partners. The findings complement existing design knowledge on visual inquiry tools, contextualizing this knowledge for the ecosystem context. By providing targeted and evaluated guidance for tool creators, the study contributes to the design of ecosystems and their prospects for success.

Keywords: Visual Inquiry Tools, Multi-Actor Ecosystem Design, Innovation Ecosystems, Business Model Development Tools, Design Science Research

1 Introduction

The increasing importance of ecosystems for future innovations, economic growth, and sustainable economies is widely recognized by researchers and practitioners alike (Wang, 2021; Baldwin et al., 2024). Multi-actor ecosystems are groups of organizations seeking to accelerate innovation through intensive collaboration to develop a joint (focal) value proposition (Adner, 2017), which integrates their respective business models (Massa, 2024; Sun et al., 2025). One example of an ecosystem ambition is the application of Internet of Things for autonomous shipping, which brings together previously unconnected actors from different industries in the search for new value creation that no single organization can create independently (Tsvetkova & Hellström, 2022).

Despite the growing relevance and advantages of ecosystems, many fail to achieve their intended outcomes (Pidun et al., 2020; Adner & Euchner, 2022; Wang, 2021). Of those organizations that have established an ecosystemic business model and launched a joint value proposition with partners, only 10% have achieved sufficient growth, i.e., generated more than 5% of company revenues from ecosystem engagements (Chung et al., 2020). Unsurprisingly, then, fewer than 15% of the 57 ecosystems analyzed by Reeves et al. (2019) across sectors and geographic regions could be sustained over time.

Interestingly, the primary reason for the majority of ecosystem failures (85%) is attributable to bad design choices rather than poor execution (Pidun et al., 2020). By comparison, start-up failure rates are similar, ranging from 70% to 90%, depending on industry and country. However, the reasons for failure differ. Start-ups mainly fail because of financing issues or a lack of customer demand (CBInsights, 2021), whereas the cause of ecosystem failures mostly lies in collaboration issues, such as poorly coordinated governance decisions (e.g., levels of co-specialization) or a misaligned ecosystem configuration (e.g., incompatible value creation mechanisms) (Pidun et al., 2020). A pertinent example is represented by the failure of the tire manufacturer Michelin to recognize that car repair shops had no incentive to adapt to its new run-flat tire ecosystem, leading to the ecosystem's downfall (Adner, 2017). Similarly, Jacobides et al. (2024) analyze the lack of success of the metaverse and ascribe it to conflicting interests and collaboration issues among dominant tech players.

The specific challenges of ecosystemic business models have been described by the innovation expert, Ron Adner, as: "Customer insights and great execution are necessary but no longer sufficient drivers of success. As delivering your value proposition has become more dependent on collaboration, finding ways to align your partners has moved to center stage" (Adner, 2021, p. xii). Consequently, designing ecosystems across various industries that fulfill evolving customer expectations is a complex collaborative challenge. It requires suitable tools, serving as boundary objects that support organizations in aligning their interests and avoiding poor ecosystem design choices (Vorbohle & Kundisch, 2024; Massa, 2024; Jacobides, 2010; Henike et al., 2020; Randhawa et al., 2021)

In recent years, visual inquiry tools (VITs), commonly referred to as "canvases", have gained popularity for addressing various wicked problems by mapping out complex concepts in a visual and structured manner (Avdiji et al., 2020). The most prominent example of a VIT is the Business Model Canvas (BMC; Osterwalder & Pigneur, 2010), which has become the quasi-standard for representing business models (Szopinski et al., 2020). However, the BMC focuses on representing the business model from the perspective of a single organization rather than the joint value creation among multiple organizations. As a result, using the BMC for ecosystem design may lead to conflicts rather than alignment (Turetken et al., 2019). Research has recognized this need and proposed various VITs for ecosystem design, such as the Value Mapping Tool (Bocken et al., 2013), the Service-dominant Business Model Radar (Turetken et al., 2019), or the Ecosystem Pie Model (Talmar et al., 2020) (see Figure 1; see Appendix Figure A1 for enlarged figures). These tools enable their users—such as corporate managers, innovators, entrepreneurs, consultants, researchers, and policymakers—to collaboratively explore and coordinate the design of possible ecosystems in a group of different organizations. But despite high interest in these VITs (e.g., the Value Mapping Tool has been cited over 1,000 times), there is currently no cross-disciplinary overview available to understand their characteristics and their underlying design.

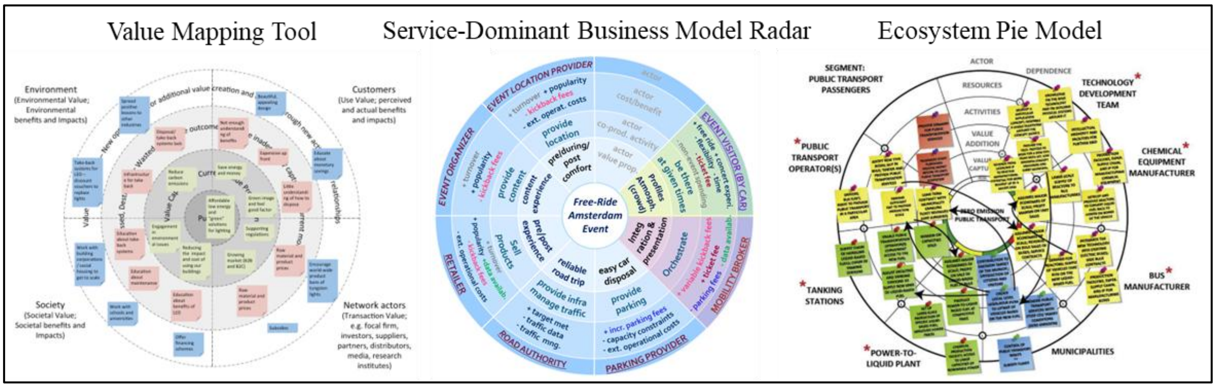

Figure 1. Three Examples of VITs for Ecosystem Design

In addition, researchers from various fields have shown that advanced tool functionality (e.g., enabled through software support) positively affects a tool's usefulness and performance (Recker, 2012; Mauerhoefer et al., 2017; Siemon et al., 2022). Accordingly, the BMC has been the subject of intensive research, aimed at, amongst others, identifying functions that enable reflection on sustainability (Schoormann et al., 2021). Moreover, despite often being rigorously embedded in theoretical concepts, research indicates that tools for business model design may cause unintended effects (Henike et al., 2020) and should be adapted to specific business model design requirements, for example, of start-ups (Lichy et al., 2025) or incumbents (Massa & Hacklin, 2020). Therefore, research on VIT improvement and advanced functionalities plays a vital role in supporting context-specific requirements more effectively (Massa, 2024; Möller & Steffen, 2022; Roschnik et al., 2024).

However, while research has primarily focused on improving the BMC, it has not yet explicitly considered the potential of advanced functionalities to enhance VITs for ecosystem design, particularly in the context of cross-organizational collaboration challenges. This consideration, however, is particularly important for two reasons. First, multi-actor ecosystems are not hierarchically controlled (Jacobides et al., 2018). This implies that the design of the ecosystem has to satisfy all its partners, and that decisions cannot be made by a single decision-maker in isolation. Poorly aligned design decisions can lead to power struggles that could impair cross-organizational group performance and derail the collaboration (Ackermann et al., 2005). Second, ecosystem design brings together people from multiple organizations across industries. This group of people is characterized by significant knowledge boundaries stemming from diverse sector-specific expertise, cultural backgrounds, management styles, and varying levels of familiarity with tools and concepts—in other words, knowledge boundaries that constrain effective collaboration (Vlaar et al., 2006; Spee & Jarzabkowski, 2009; Bittner & Leimeister, 2014). Failure to overcome such boundaries may lead to friction among ecosystem partners, and ultimately undermine the entire ecosystem opportunity. Therefore, advanced functionalities are essential to help address the specific collaboration challenges of ecosystem design (Vorbohle & Kundisch, 2024). These functionalities should be carefully elaborated and evaluated, because impractical or insufficient tools could result in collaboration failure (Zuzul, 2019).

Given the great potential of multiple organizations collaborating to tackle future technological innovation and sustainability issues, it seems imperative to address current limitations in order to take VITs for ecosystem design to the next level. Current research lacks context-specific design knowledge related to functionalities for enhancing ecosystem VITs beyond the existing abstract design theory proposed by Avdiji et al. (2020). More detailed guidance is needed, therefore, to inform tool creators how to optimize a VIT for the challenge of cross-organizational alignment and thus to reduce ecosystem failures.

Accordingly, this paper is guided by two research questions:

RQ1: What visual inquiry tools for ecosystem design currently exist, and what are their characteristics?

RQ2: How can functions for VITs be designed to improve cross-organizational collaboration in the design of ecosystems?

To address these research questions, I follow the design science paradigm (Hevner et al., 2004), and employ a stage-based research process, as outlined by Recker (2021). This research process is informed by the methodology for design science research proposed by Peffers et al. (2007), and combines it with ideas from the design archaeology approach (Chandra Kruse et al., 2019).

The research process consists of four stages. The first stage aims to identify and analyze the current VIT landscape. To this end, I consider VIT design taxonomies and two (kernel) theories: 1) the design theory for VITs, and 2) the ecosystem-as-structure view (both explained in section 2). In stage two to four, I investigate how potential users utilize and perceive the tools to develop empirically grounded and evaluated prescriptive design knowledge in the form of concrete functionalities (formulated as design principles) and tangible design features. The design principles are intended to contextualize design knowledge for VITs for the problem situation (i.e., multi-actor ecosystem design), while the design features help to translate the functionalities (*what* should be done) into the *how* of implementation (Strohmann & Khosrawi-Rad, 2025). This novel design knowledge will contribute to the growing literature on VITs and provide a foundation for researchers and practitioners to select or (re-)design VITs. It will enhance the utility of VITs for multi-actor ecosystem design and help organizations collaborate more effectively with their partners to mitigate the risk of ecosystem failure.

2 Background

2.1 Multi-Actor Ecosystems

Ecosystem perspective: Based on insights from natural ecosystems, a business ecosystem was first conceived as companies working together toward a common goal while maintaining an open exchange with their environment to foster continuous innovation (Moore, 1993). This ecosystem perspective of Moore (1993) allows to understand industry coopetition—organizations that work cooperatively and competitively—and is currently described as the coevolution view on ecosystems (Hou & Shi, 2021). More recent literature on multi-actor ecosystems offers a more narrow definition, which conceptualizes the ecosystem as a structure that encompasses activities, actors, positions, and links (Adner, 2017). Structuralists argue that ecosystems form around one joint value proposition and highlight the role of modularity and complementarities as defining features (Jacobides, Cennamo, & Gawer, 2024). Hence, a joint value proposition serves as the system's foundation, providing a reference point for other organizations to contribute resources and activities based on co-specialization. In addition, hierarchical control and contractual mechanisms are absent from the ecosystem governance (Jacobides et al., 2018). This means that it is essential that the ecosystem benefits all contributing organizations to a satisfactory degree. Thus, the structural perspective singles out key characteristics that distinguish ecosystems from other concepts, such as platforms (Jacobides, Cennamo, & Gawer, 2024) and supply chains (Kapoor, 2018).

While several definitions have been proposed for different types of ecosystems (e.g., business, innovation, entrepreneurial, circular, platform), they are not applicable across domains and studies (Hou & Shi, 2021; Thomas & Autio, 2020). In this paper, rather than focusing on terminological differences, I refer to multi-actor ecosystems as "interorganizational structures allowing firms to align their interests to collaborate and build a joint value proposition" (Jacobides, Cennamo, & Gawer, 2024, p 3), and apply the ecosystem-as-structure view to identify and analyze VITs because "if the VP [Value Proposition] and the required complementarities could be identified ex ante, the structure view is quite useful in guiding the ecosystem design" (Hou & Shi, 2021, p. 8).

Multi-actor ecosystem design: The question of how ecosystems emerge remains a topic of ongoing discussion among scholars (Suominen et al., 2019; Lingens et al., 2023). Recent research has identified two possible design approaches that result from the absence of formal contracts. The top-down approach is associated with one central leading orchestrator (ecosystem planner) developing the ecosystem design and then recruiting ecosystem participants to predefined roles (Hoffmann et al., 2022; Autio, 2021). In contrast, the bottom-up approach is characterized by an inclusive orchestration, where the ecosystem design is a collaborative discovery process, typically led by one or more orchestrators. Organizations identify one (or several) joint value propositions together and then design an ecosystem (or multiple ecosystems) around each identified joint value proposition (Hoffmann et al., 2022; Autio, 2021). To create an alignment structure, organizations involved in this process look not only at their own business model but also seek to identify other organizations' resources and activities which, by complementing their own business model, could represent a competitive advantage and contribute to greater value capture for all (Vorbohle & Kundisch, 2024; Adner, 2017). The case study of TiVo, for example, illustrates how an ecosystem can be developed collaboratively through a multi-actor process, where the future ecosystem structure is not known to the partners at the outset (Ansari et al., 2016). A similar iterative development process among partners is described by Dattee et al. (2018) where "actors discover, rather than plan, the ecosystem approach" (p. 490). Hence, multi-actor ecosystems often do not emerge from the draft of one ecosystem planner. Rather, it would appear that "the messy reality of ecosystem creation […] call[s] for a more bottom-up approach" (Autio, 2021, p.7). Interestingly, Lingens et al. (2021), who analyzed ten case studies to understand how organizations shape the design of an ecosystem, concluded that a key factor for determining the extent of the involvement of multiple actors in the ecosystem design process were the knowledge distance (between the existing business knowledge and the field of business the ecosystem focuses on) of the orchestrator(s) at the helm of the design process. While the structural perspective (e.g., Adner,

2017) simply side-stepped the need for a collaborative design process—or rather, assumed a top-down implementation through a value blueprint approach (Adner, 2013)—the top-down approach is often constrained in uncertain environments with high innovation ambitions (Autio, 2021). In reality, it has also been found that ecosystems can emerge through both planned blueprints from a central leading orchestrator, which are augmented by collaborative design approaches (Sunner, 2021; Lingens et al., 2023). Therefore, I consider this research to be particularly relevant in supporting the "need" (of the problem space) (see Maedche et al., 2019) for designing multi-actor ecosystems with high innovation potential, which emerge at least partly through a collaborative, bottom-up approach.

In a bottom-up approach to designing ecosystems, cognitive artifacts, such as visual representations that demonstrate how to create joint value, play a crucial role (Randhawa et al., 2021; Vorbohle & Kundisch, 2024). When used as boundary objects, cognitive artifacts can not only help decision-makers manage the complexity of ecosystem transformation but also support them in their efforts of aligning their value creation and value capture mechanisms simultaneously with ecosystem partners, and overcoming cognitive barriers and resistance to change (Randhawa et al., 2021, p. 124). VITs have the potential to function particularly well as effective boundary objects in a bottom-up approach, as they open up the possibility to visualize the ecosystem design and support the process of jointly ideating, prototyping, and discussing different options.

2.2 Visual Inquiry Tools

Definition and benefits: The popularity of the BMC has led researchers and practitioners to develop similar artifacts—referred to as VITs—in various fields (Thoring et al., 2019), for example for design science research projects (Vom Brocke & Maedche, 2019) or for developing data products (Hasan et al., 2025). For the definition of a VIT, I follow that proposed by Avdiji

(2018, p. XV): “a tool that frames the elements of a wicked problem and represents them in a shared visual problem space that team members can use to inquire into the problem.”

VITs have three main advantages: 1) they provide a shared language, comprehension, and framing of the problem to solve; 2) they assist diverse users in exploring new solutions by providing support for structuring and delimiting the problem; and 3) they allow for a collaborative design process that has proven effective in enhancing social engagement within groups (Missonier et al., 2020), such as constructive teamwork (Eppler et al., 2013). Therefore, VITs serve as boundary objects that facilitate communication and collaboration across knowledge boundaries, enabling stakeholders to align their ideas and expectations (Schwarz & Legner, 2020). Research on cognition and business models argues that these tools also help to reduce cognitive biases, enhance ideation, increase coherence, and influence managers’ decision-making (Shepherd et al., 2023; Massa & Hacklin, 2020). Despite their usual association with the BMC, VITs can differ in terms of form, size, and shape.

Design knowledge for VIT: To support this emerging field and provide a theoretical foundation for the development of VITs, Avdiji et al. (2020) have theorized VIT design by formulating a design theory, as most previous developments of VITs merely relied on the tool creators’ intuitions, or on the redesign of existing tools (e.g., the BMC). Their design theory was built on knowledge from three successful design science research projects (BMC, Value Proposition Canvas, and Team Alignment Map) and suggests 12 design principles, organized into three categories: 1) structuring of the design problem through the creation of a conceptual model; 2) facilitating communication between users through a shared visualization based on the conceptual model; and 3) defining directions of use for effective joint inquiry. Moreover, they propose five testable propositions to address, amongst others, the tool’s efficacy and effectiveness (see Appendix Table A2 for further details on the design theory).

Avdiji et al. (2020) derived their design theory from a cross-project analysis that included design knowledge applicable to all three investigated VIT design projects from different problem domains. While this led to a valuable design theory with a high degree of projectability, its trade-offs included limitations in terms of fitness and contextualization for specific wicked-problem domains (see Vom Brocke, Winter, et al., 2020). To extend the design theory with contextualized design knowledge, Roschnik (2025) proposed design principles for transformation canvases, abstracted from the development of the Agile Transformation Canvas. However, to the best of my knowledge, no further contextualization of the design theory exists. In addition, two studies have analyzed existing VITs for various fields, and created taxonomies to inform tool creators on possible design options, for example, for design output (Möller & Steffen, 2022) or integrated elements (i.e., semantic constructs) (Thoring et al., 2019).

Advanced functionalities and software support: According to Avdiji et al.'s (2020) design theory, VITs can be represented either in an analog form (i.e., on a paper-based poster version) or instantiated into software (i.e., computer-aided design). Software-supported VITs enable users to collaborate on a design project, regardless of time, location, or organizational boundaries (Thoring et al., 2019). In terms of team performance and user satisfaction the software-enabled VITs have been found to outperform analog versions in inter-organizational settings (Comi & Eppler, 2011). Additionally, researchers have highlighted the potential for software support for VITs to design business models more efficiently than through analog versions (Osterwalder & Pigneur, 2013; Veit et al., 2014).

Roschnik et al. (2024) further distinguish between "digitization" and "digitalization" of VITs. Digitization refers to instantiating VITs on online collaboration platforms (e.g., *Miro* or *Mural*) that facilitate remote collaboration and have been proven to be beneficial for developing business models using the BMC (Venter & Vries, 2024). Digitalization, however, goes further by enabling additional functionalities that are tailored to specific domains or use cases. Such customization is becoming increasingly important when faced with the complex, wicked problems of the future (Roschnik et al., 2024). Unsurprisingly, the digitalization of VIT is considered a highly relevant research area (Möller & Steffen, 2022; Roschnik et al., 2024).

So far, research on the digitalization of VIT has primarily focused on the BMC. Researchers have analyzed the functions of software-based versions using a taxonomy (Szopinski et al., 2020), and developed design principles and features pertinent to sustainability (Schoormann et al., 2021). Here, Schoormann et al. (2021) distinguish between features suitable for analog settings and those that require software support and suggest, for example, in the context of user collaboration, providing a discussion board to enable the tracking and justifying of design decisions. Other collaboration-related functionalities for BMC improvement include, for example, user and role management (Szopinski et al., 2020), the creation of snapshots for tracking changes (Zec et al., 2014), allow different user groups to create their own semantic meanings (Fritscher & Pigneur, 2014), provide a repository for central terms used (Ebel et al., 2016), or being able to identify affected (intra-organizational) stakeholders (Schwarz & Legner, 2020). These advanced functionalities for VITs—potentially supported by software—bear the potential to enhance the design process of ill-structured problems (Eppler et al., 2013). However, despite work that offered conceptually derived design requirements for ecosystemic business model tools in general (i.e., not specifically for VITs) (Vorbohle & Kundisch, 2024) and the requirements for conceptual modeling of ecosystems (Tsai et al., 2021), research on functionalities required for VITs in designing multi-actor ecosystems is still lacking.

3 Research Approach

3.1 Observing Artifacts to Derive Prescriptive Design Knowledge

A design science research project can contribute to scientific knowledge in different ways. Traditionally, it involved the development of a new artifact as part of a project, to help solve a problem (referred to as design entity), or by developing not only a new artifact but also knowledge about its design (referred to as design knowledge). However, creating an artifact is not obligatory for the creation of design knowledge (Molla et al., 2024; Vom Brocke & Maedche, 2019). A third category has been identified, where instead of a new artifact being proposed, the design and user perceptions of an existing "artifact-in-use" are analyzed through an observational approach (Vom Brocke, Hevner, & Maedche, 2020). Here, the contribution to design knowledge is made through an aggregation of existing knowledge, or the improvement of the artifact(s) under observation is envisioned (Recker, 2021; Chandra Kruse et al., 2019). According to Maedche et al. (2021), regardless of whether design knowledge is derived from observation or from the construction of a new artifact, it can be prescriptive or descriptive. I position my work within the "deployment" cluster of Maedche et al.'s (2011) design science contribution framework, where the researcher's role is observational, and the aimed-for knowledge contribution is prescriptive.

The aim of this design science research project is to develop design knowledge in the form of design principles and design features for a specific class of artifacts in a distinct problem space, as demonstrated, for example, by Schoormann et al. (2021) in the context of sustainable business modeling. My problem domain is the collaborative design of multi-actor ecosystems, and the class of artifacts under consideration are VITs. Building on the mid-range design theory of VITs by Avdiji et al. (2020), I inductively derive context-specific design principles for VITs that aim to support the design of multi-actor ecosystems, and that do not lose sight of the additional challenges represented by cross-industry and power-balanced collaborations (unlike the projects considered for developing the VIT design theory). The contextualized design principles can be viewed as a nascent design theory (Gregor & Hevner, 2013), which is valuable for a subset of VITs, as exemplified by Roschnik (2025) for transformation canvases.

3.2 Research Process

My research process is informed by the methodological process suggested by Recker (2021), who adapted the methodological guidelines of Peffers et al. (2007) using a context-initiated entry point, and combined it with ideas from the design archaeology approach (Chandra Kruse et al., 2019; Molla et al., 2024). Such a staged research process has been proven to be effective for developing and revising design principles (e.g., Seidel et al., 2018), and is supported by Rai (2017), who claims that design science research does not necessarily have to follow an explicitly predefined process.

In the remainder of this subsection, I present my research process, which consists of four stages (see Figure 2). Although these stages are presented consecutively, the execution of the steps followed their logical connection, and was partly iterative (following Recker, 2021). For instance, the definition of the objectives of a solution (stage 3) was intertwined with the VIT analysis (stage 1) and the user feedback analysis (stage 2). Similarly, insights gained from evaluating the initial design knowledge (stage 4) led to a re-analysis of user requirements (stage 2) and the revision of the initial design knowledge (stage 3).

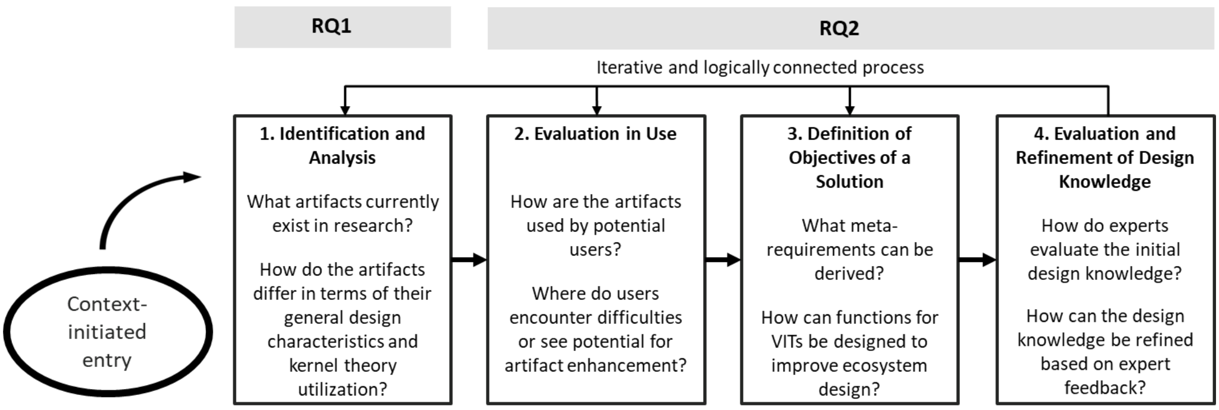

Figure 2. Research Process (adopted from Recker, 2021)

Stage 1: Identification and Analysis

What artifacts currently exist in research? (Step 1a): To identify existing VITs for ecosystem design, I conducted a systematic literature review following the guidelines of Webster and Watson (2002). I defined four inclusion criteria for the identification of an artifact. To be included, an artifact has to: 1) be defined as VIT; 2) consider simultaneously the multiple actors that can contribute to the ecosystem design; 3) include the determination of a joint value proposition and a business model perspective; and 4) be published in an established academic journal (VHB Ranking 2024 ≥ C)[1] to build on high-quality VITs.

I applied a three-step search process. First, I relied on literature reviews that either considered modeling tools for ecosystems (Tsai et al., 2022; Arreola González et al., 2019) or included a multi-actor perspective on business modeling (Szopinski et al., 2022). This analysis resulted in one relevant publication.

Second, I conducted a keyword search across three databases (EBSCO, Web of Science, and AIS eLibrary), which cover the majority of scientific publications in the field of information systems and management. I searched for the term "ecosystem" or "business model" because both terms can be relevant for the design of a joint value proposition by multiple organizations. These terms are combined with terms that indicate the presence of a VIT, including the terms "visual inquiry" and "canvas", as well as terms used to refer to VITs in prior research (i.e., "boundary object", "visual tool" or "collaboration tool"). I searched in titles, abstracts, and keywords, using both the singular and plural forms of the terms. The search included publications between 1993, when research on ecosystems became prevalent, and November 2024. The search strategy resulted in 1,193 publications. The relevance of each paper was assessed in terms of the four above-mentioned inclusion criteria. Where this process was insufficient to assess a paper's relevance, the entire publication was read. For example, I excluded multiple publications that proposed VITs for ecosystem design but only from a single organization's perspective (e.g., Hoveskog et al., 2018). At the end of the second step, I identified an additional five publications. In a third step, I conducted a backward search, analyzing the references of already identified and relevant publications, which allowed me to find a further three relevant contributions.

[1] https://www.vhbonline.org/en/services/vhb-rating-2024/area-ratings

How do the artifacts differ in terms of their general design characteristics and kernel theory utilization? (Step 1b): To understand and synthesize existing knowledge about the identified VITs, I engaged in design archeology from the designer's perspective (Chandra Kruse et al., 2019). This involved systematically analyzing the corresponding publications, complementary publications (e.g., Talmar et al., 2025), and supplementary information (e.g., explanatory videos) to gain insights into key design decisions, understand the applications the designer envisioned, and how the artifacts were created and evaluated. To structure these insights, I drew on proposed VIT characteristics (Möller & Steffen, 2022; Thoring et al., 2019) and developed a dedicated framework for tool comparison. In a second step, I analyzed the identified VITs considering two main (kernel) theories: 1) the ecosystem-as-structure view proposed by Adner (2017), and 2) the design theory for VITs proposed by Avdiji et al. (2020).

Stage 2: Evaluation in Use

How are the artifacts used by potential users? (Step 2a): To understand how the VITs are used and to identify potential collaboration challenges, I engaged in design archaeology from the user's perspective (Chandra Kruse et al., 2019). This involved selecting three different VITs and analyzing their 'in-use' in terms of intended and unintended effects. The three VITs (Talmar et al., 2020; Turetken et al., 2019; Konietzko et al., 2020) were selected based on the VIT comparison (step 1b), with the purpose of choosing well-elaborated tools from different research and focus areas. At the same time, the three VITs differ in terms of their kernel theory utilization but were deemed suitable to fit the same ecosystem design challenge.

I conducted a digital "artifact-in-use workshop" with 135 students who participated in a bachelor-level course on methods for developing digital business models, but were enrolled in a range of disciplines, including information systems, informatics, international business studies, business and economics, and engineering. Before the workshop, the students were trained on business model design (e.g., using the BMC) and showcased their knowledge through two obligatory group work assignments using the collaboration platform *Miro*. After the group work assignments, the students were trained on giving constructive feedback and provided feedback on two other assignments (the course structure follows Szopinski, 2019). In the artifact-in-use workshop, the students were divided into groups of five and introduced to the ecosystem design challenge. Hence, each of the three selected VITs was used by nine different groups. The design challenge I gave them was an adapted use case from the automotive industry, specifically focusing on the discovery of a predictive maintenance multi-actor ecosystem. Students in each group were assigned to one of the ecosystem actor roles, to cover different roles in the same group (i.e., supplier, car repair shop, insurer, or two different car manufacturers). In addition, the students received important information on how to use the respective VIT, for example, supplementary descriptions or video tutorials. The workshop was conducted digitally via *Miro* and *Zoom* break-out rooms for communication. The time for the ecosystem design challenge using the VITs was 70 minutes. Additionally, I conducted an in-person thinking-aloud workshop with 23 students from various faculties who lacked business model design skills, using the Ecosystem Pie Model (Talmar et al., 2020).

Where do users encounter difficulties or see potential for artifact enhancement? (Step 2b): After the digital artifact-in-use workshop, the students were required to complete a survey and questionnaire that included eight open-ended VIT evaluation questions. To formulate the open-ended questions, I leveraged four of the five testable propositions from the design theory of Avdiji et al. (2020) (see Appendix Table A3 for details). The user feedback was then analyzed using a thematic coding approach to identify and highlight relevant data chunks, resulting in a comprehensive understanding of the key themes for each artifact instance (Braun & Clarke, 2006). In addition, I conducted an artifact analysis by examining the workshop outputs (i.e., the completed VITs and their traces of use) to further understand the use of each artifact instance (following Thoring et al., 2020). Together with the observations from the thinking-aloud workshop, the key themes of each instance were analyzed and aggregated into cross-instance key themes.

Stage 3: Derivation of Design Knowledge

What meta-requirements can be derived? (Step 3a): Based on the VIT analysis (stage 1) and the derived cross-instance key themes (stage 2), I formulated the meta-requirements[2]. Meta-requirements are abstract requirements that describe the goals and needs that a class of artifacts should fulfill, thereby supporting the formulation of design principles. Hence, my meta-requirements were aimed to address not a single artifact instance (i.e., a specific VIT for multi-actor ecosystem design) but rather the class of artifacts (Walls et al., 1992).

How can functions for VITs be designed to improve ecosystem collaboration? (Step 3b): The envisioned functions to enhance the (re-)design of VITs and improve cross-organizational collaboration are formulated as design principles. Design principles are a form of prescriptive knowledge and an established approach in design science research aimed at capturing design knowledge about a class of artifacts (Gregor et al., 2020). To ensure that the design principles are developed in a methodologically rigorous way, I considered the guidelines proposed by Möller et al. (2020). Figure 3 summarizes the choice of characteristics of the design principles, using the taxonomy of Möller et al. (2020) as an overview. I formulated the initial set of design principles based on the derived meta-requirements that encapsulate both artifact function and user activity (Gregor et al., 2020). Each design principle was required to address at least one meta-requirement. As the principles did not assist the design of an artifact ex-ante, but were formulated ex-post through an observational approach, they were derived through a reflective research approach. Since design principles are a rather abstract form of design knowledge, and rarely come with concrete guidance on how to implement them, I translated them into design

[2] See Appendix Figure A4 for an overview of the data generation and analysis procedure that led to the formulation of meta-requirements and the subsequent creation of design knowledge.

features that constitute one way of instantiating the design principle (following Meth et al., 2015).

Dimension	Characteristics				
Perspective	Supportive	Reflective			
Research Design	DSR	A(D)R	Qualitative	Case Study	
Meta-Requirement Source	Literature	Theory	Interviews	Workshops/ Focus groups	None
Design Principle Design	Derived	Extracted	Responsive		
Iterations	Single	Multiple			
Evaluation	Expert/ User Feedback	Instantiation/ Field testing	Argumentation		
Formulation	Free	Based on Template			

Figure 3. Design Principles' Development Characteristics (highlighted in grey) based on the taxonomy of Möller et al. (2020)

Stage 4: Evaluation and Refinement of Design Knowledge

How do experts evaluate the initial design knowledge? (Step 4a): I drew on existing guidance to evaluate the extent to which the initial set of proposed design principles and design features helps to enhance the class of artifacts (Iivari et al., 2021). For a discussion of the principles and features, I conducted semi-structured interviews with 16 experts, using Iivari et al.'s (2021) framework. Half of the experts were researchers with relevant knowledge of developing VITs and/or who work(ed) in ecosystem design projects, and the other half were practitioners familiar with business model/ ecosystem tooling, such as consultants or in-house management advisors. The experts provided insights from a range of industries (e.g., energy, electric mobility, banking, pharma), years of experience (from 1+ to 20+ years), and educational backgrounds (e.g., business, informatics, etc.), and were based in different geographic regions (Germany, Finland, Switzerland, and the USA). A detailed list of interviewees is provided in Appendix Table A5.

How can the design knowledge be refined based on expert feedback? (Step 4b): I analyzed both quantitative feedback (based on the criteria of Iivari et al., 2021) and qualitative feedback (i.e., experts' feedback on the design principles and features, and suggestions for additional requirements they deemed necessary). For the conversion of speech to text (qualitative feedback), I used *Microsoft Word 365* to make a verbatim transcript and corrected misspellings. I then conducted a process of top-down coding (Urquhart, 2013) where the expert feedback was compared with the initial design knowledge, using *MAXQDA*. Where I identified discrepancies between intended functionality outcomes and the experts' feedback, I reanalyzed the user feedback from stage 2 and explored alternative functional properties that might create the intended outcome. Where necessary, the design knowledge was revised or refined, resulting in a final set of design principles and design features.

4 Results

4.1 Identification and Analysis of Existing VITs

The systematic literature review revealed nine relevant VITs for multi-actor ecosystem design that meet the defined inclusion criteria. Table 1 lists all the identified tools in chronological order. The first VIT (#1) was published in 2013 to support sustainable business modeling. Most of the tools (seven out of nine) were published in 2019 or later, reflecting the growing interest in ecosystems, and a more clearly defined ecosystem concept (Hou & Shi, 2021).

An important distinction lies in the tools' focus areas and tool objectives, which range from sustainable business modeling (#1, #2) and service-dominant business model design (#3) to focus areas such as circular ecosystems (#4, #6, #7), and innovation ecosystems (#5, #9). Five tool objectives relate to sustainability (#1, #2, #4, #6, #7), showing the importance of multi-actor collaboration for sustainability. In terms of applied research methods, five tools are rooted in design science research, demonstrating iterative development and theoretical grounding. Only two tools stem from integrative approaches (#2, #9), combining existing VITs (e.g., the BMC) to address ecosystem design. Moreover, the findings show the presence of similar types and forms. Only one VIT (#4) deviates from a canvas structure, consisting of a card deck. Six publications develop a round canvas structure, presenting the joint value proposition in the middle and each actor as a slice. Another important differentiation lies in the semantic constructs, that is, the number of conceptual elements each tool employs. These range from minimalist sets with 4 or 5 constructs (#1, #3, #7, #8) to more detailed tools with over twenty different constructs (#9).

The comparative analysis of VITs as seen through the lens of Adner's (2017) ecosystem structure elements reveals differences in their theoretical alignment with the ecosystem-as-structural perspective (Table 2). Most tools show a strong emphasis on actors and activities—the two foundational components of ecosystem structures (Althaus et al., 2025)—while positions and links, which are critical for understanding structural interdependencies, are underrepresented. Only two VITs (#4, #8) explicitly include these deeper structural elements of ecosystem design.

From the design-theoretical perspective of Avdiji et al. (2020), the tools exhibit a high level of convergence around functional principles (DP2.1–2.3) and directions for use (DP3.1–3.3), particularly in enabling ideation, prototyping, and presentation (Table 2), which nearly all the tools support. However, only three VITs (#1, #5, #6) were built on an explicit conceptual model, which is an essential design requirement according to Avdiji et al. (2020). Therefore, due to the lack of a conceptual model, these VITs considered the design principles of conceptual framing (DP1.1), rigor and relevance (DP1.2), and parsimony (DP1.3) less frequently.

Table 1. General Characteristics of VITs for Multi-Actor Ecosystem Design (based on Möller & Steffen, 2022; Thoring et al., 2019)

No.	Tool Name	Research Paper	Journal	Stated Focus Area	Tool objective	Design Method	Design Origin	Design Output	Type/ Form	Elements	Evaluation Strategy	Methodological Support
#1	Value Mapping Tool	Bocken et al. (2013)	Corporate Governance	Sustainable Business Models	"to support business modelling for sustainability by assisting firms in better understanding their overall value proposition"	Case Study	New	Stand-Alone	Canvas/ Round	4	Case Studies, Workshops	Not provided
#2	Business Innovation Kit for Value-based Networks	Breuer and Lüdeke-Freund (2017)	International Journal of Innovation Management	(Sustainable) Business Model Networks	"a conceptual framework for values-based innovation management, […], to support the creation of values-based networks and business models"	Integrative	Adapted	Part of a Toolkit	Canvas/ Rectangular	13	Exemplary workshops	Provided
#3	Service-Dominant Business Model Radar	Turetken et al. (2019)	Business & Information Systems Engineering	Service-dominant Networks (Ecosystems)	"a visual template to represent service-dominant business models, which depicts the way that a network of organizations co-creates a value for a specific customer group through a solution-oriented service"	Design Science Research	New	Stand-Alone	Canvas/ Round	5	Workshops, Survey questionnaire	Provided
#4	Circularity Deck	Konietzko et al. (2020)	Sustainability	Circular Ecosystems	"to help firms to analyze, ideate and develop the circularity potential of their innovation ecosystems"	Design Science Research	New	Stand-Alone	Template and Card deck	4 (Template) 54 (Card Deck)	Workshops	Not provided
#5	Ecosystem Pie Model	Talmar et al. (2020)	Long Range Planning	Innovation Ecosystems	"a strategy tool to map, analyze and design (i.e., model) innovation ecosystems"	Design Science Research	New	Stand-Alone	Canvas/ Round	9	Workshops	Provided
#6	BM³C² Framework	Boldrini and Antheaume (2021)	Journal of Cleaner Production	Circular Ecosystems	"[to build] circular ecosystems by visualizing the parties involved, connecting and aligning their business models"	Conceptual	New	Stand-Alone	Canvas/ Rectangular	19	Workshops, Survey questionnaire	Not provided
#7	Boundary Tool	Velter et al. (2022)	Circular Economy and Sustainability	Circular Multi-Stakeholder Business Model Innovation	"to help companies engage with multiple stakeholders to innovate sustainable business models"	Design Science Research	New	Stand-Alone	Canvas/ Round	5	Workshops, Survey questionnaire	Provided
#8	Integrated Business Ecosystem Pie Model and BMC	Goncearuc et al. (2022)	Journal of Business Research	Business Ecosystems	"[to help] companies: (a) to participate in a fast technologically evolving market, (b) to determine the desired positions into the ecosystem, (c) to come up with detailed definitions of the (current or desired business models and (d) to construct the roadmaps for their evolution"	Integrative	Adapted	Part of a Toolkit	Canvas/ Round	5	Use Case	Provided
#9	Ecosystem Clock Model	Jütting (2024)	Journal of Cleaner Production	Innovation Ecosystems	"to analyze and shape innovation ecosystems' strategic design across different lifecycle phases"	Design Science Research	New	Stand-Alone	Canvas/ Round	21	Workshops	Not provided

Table 2. Analysis of VITs for Multi-Actor Ecosystem Design based on Kernel Theories

Kernel Theory	Construct/ Design Principle	Tool Number								
		#1	#2	#3	#4	#5	#6	#7	#8	#9
Elements of Ecosystem Structure (Adner, 2017)	Activities	x	x	x	x	x		x		x
	Actors	x	x	x	x	x	x	x	x	x
	Positions					x			x	
	Links					x	x			
Design Theory for Visual Inquiry Tools (Avdiji et al. 2020)	Conceptual Model	Yes	Not specified	Not specified	Not specified	Yes	Yes	Not specified	Not specified	Not specified
	DP1.1 – Frame	x				x	x			
	DP1.2 – Rigor & Relevance	x				x	x			
	DP1.3 – Parsimony	x				x				
	DP2.1 – Functionality	x	x	x	x	x	x	x	x	x
	DP2.2 – Arrangement	(x)				x	x			
	DP2.3 – Facilitation		x		x			x		
	DP3.1 – Ideation:	x	x	x	x	x	x	x	x	(x)
	DP3.2 – Prototyping	x	x	x	x	x	x	x	x	x
	DP3.3 – Presentation	x	x	x	x	x		x		x

Legend: (x) = only partially fulfilled.

4.2 Evaluation in Use of Selected VITs

To understand the VITs from a user perspective and analyze the practices they enable, I conducted a digital artifact-in-use workshop with 135 students, who were divided into 27 groups of five individuals. After the workshop, the students provided feedback on their workshop session by answering eight open-ended questions, resulting in over 50,000 words of feedback. Students provided feedback on, for example, the weaknesses they experienced with the tool (e.g., “I would see the lack of detail in the co-created value-in-use as a weakness”; “[the VIT] has ignored many relevant aspects of designing a business model, while also being too extensive”) and suggested ideas for how to improve the tool (“Perhaps a hierarchy would be useful, or an umbrella model”). Through this process and the additional observations from the thinking-aloud workshop, I gained valuable insights into the merits and drawbacks of each of the three VITs, and derived cross-instance key themes for their enhancement. In addition, the 27 VIT outputs were analyzed and compared, further increasing understanding of the artifact-in-use. Figure 2 shows examples of the output of three groups for each selected VIT (#3, #4,#5).

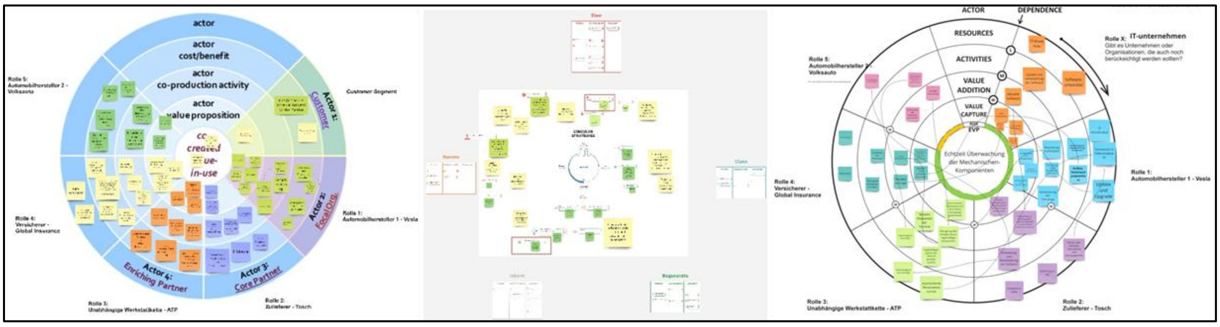

Figure 4. Examples of Results from the Artifact-In-Use Workshop (sticky notes are in German but their legibility is unnecessary for the purpose of illustration)

4.3 Definition of Solution Objectives: Deriving Initial Design Principles and Design Features for VIT Enhancement

Based on the cross-instance key themes and the preceding stage of VIT analysis, I derived five meta-requirements aimed at supporting the formulation of design principles and features (Table 3). These meta-requirements reflect both the cognitive and collaborative complexities of designing multi-actor ecosystems with VITs.

First, VITs should *facilitate conceptual and terminological clarification* (**MR1**) by fostering a shared understanding of key terms and concepts among users from diverse organizations and backgrounds. This addresses frequent misalignments in interpretation that can considerably undermine collaboration. Second, VITs should *ensure cognitive ease and usability* (**MR2**), notably by minimizing visual complexity and, thereby, the cognitive efforts of users to enable quicker engagement and comprehension. Third, I identified the requirement to *enable iterative thinking and design reflection* (**MR3**), ensuring that the VITs support discussions, feedback loops, and collective learning throughout the design process. Fourth, VITs should *support contextual adaptability and scalability* (**MR4**), allowing users to flexibly adjust the VIT's structure to accommodate specific industry or ecosystem contexts. Finally, they should *facilitate the visualization of interdependencies and surface tensions* (**MR5**) to enable users to anticipate and address any challenges arising from interdependencies, conflicting interests, and coordination among ecosystem actors, which are frequently the source of ecosystem failure.

Table 3. Meta-Requirements for Enhancing VITs for Multi-Actor Ecosystem Design

Salient user observations and feedback (stage 2) and VIT analysis observations (stage 1)	Cross-instance key themes	Meta-requirements (MR)
• Struggle to distinguish between key elements such as "value addition" and "value capture", leading to divergent outputs • Terms such as "service", "artificial intelligence", "circular economy" or "dependency" were understood differently, complicating alignment and joint decision making • Unknown terminology (e.g., circularity terms) overwhelmed users unfamiliar with the domain	Struggle to understand and align core concepts and terminology due to different backgrounds and prior knowledge, resulting in poorly conceived ecosystem design outputs and group performance.	**MR1:** Facilitate conceptual and terminological clarification
• Visual complexity (e.g., dense diagrams, confusing arrows) hindered engagement • Users found it essential that additional information is accessible, pre-structured, and easy-to-understand • Scientific jargon and unclear elements hinder engagement • VIT Analysis showed that most tools do not make use of images or metaphors to increase usability. However, the visualizations of VIT #4 were found to be very useful	Difficulties in using the VITs due to cognitive overload and overwhelming ecosystem outputs, while supplementary information increased user satisfaction.	**MR2:** Ensure cognitive ease and usability
• Reflection and critical discussions happened only (if at all) at the end of the design phase, not during the phase • Absence of version history or feedback mechanism led to the loss of insights that could be valuable to design decisions during collaboration • VITs state that discussions are only facilitated by a workshop facilitator	Lack of VIT support for iteration, idea discussion, and group-level reflection.	**MR3:** Enable iterative thinking and design reflection
• Users wanted to bring in their specific ecosystem context or industry-specific cases • Templates were seen as too rigid, with limited flexibility to adapt fields • Users suggested optional or dynamic role structures based on actor needs • VIT analysis highlighted the benefits of actor scalability (flexible number of actors)	Fixed canvas templates and predefined roles do not always align with the ecosystem context, ecosystem size, or process flow.	**MR4:** Support contextual adaptability and scalability
• Arrows and connections quickly became cluttered and unreadable; users suggested visual grouping or alternative linking methods (e.g., colors) • Reported difficulties in assigning individual users to the respective design inputs • Design conflicts (e.g. conflicting objectives of the actors) could not be visually marked • Lack of conflict visibility led to superficial integration of actor perspectives • VIT analysis showed that only two tools reveal interdependencies	Struggle to visualize and interpret actor relationships and conflicting ecosystem perspectives.	**MR5:** Facilitate the visualization of interdependencies and surface tensions

Based on these five meta-requirements, I formulated an initial set of six design principles. Table 4 shows the relationship between the meta-requirements and the derived design principles. Since design principles are usually not tied to specific implementation details, I follow Meth et al. (2015) in translating the design principles into design features based on insights gained from deriving the meta-requirements and design principles. These design features are one way of instantiating the design principles (Table 4).

Table 4. Initial Set of Design Principles and Design Features

Design principles (DP)	Derived from MR	Design principle specification	Design features (DF)
DP1: Unified understanding	MR1	Provide functions for detecting and aligning different conceptual and terminological understandings, enabling users to achieve consistent interpretations.	**DF1.1:** Terminology checkpoints that request users to discuss and confirm a shared understanding. **DF1.2:** Dynamic glossary where users can describe their current understandings.
DP2: Accessibility	MR2, MR3	Provide functions for improving intuitive comprehensibility and reducing cognitive load, enabling users to interact more easily.	**DF2.1:** Symbolic language familiar to the user. **DF2.2:** Instructions and supplementary guidelines. **DF2.3:** Annotated examples for VIT elements.
DP3: Iteration and reflection	MR3	Provide functions for iterative thinking and reflection, enabling users to iteratively revise and improve their input over time.	**DF3.1:** Systematic version tracking. **DF3.2:** Visual space for feedback and lessons learned. **DF3.3:** Reflection questions to reassess the design regularly.
DP4: Modularity	MR2, M4, M5	Provide functions for minimizing cognitive efforts caused by syntactic (e.g., visual notations) and semantic (e.g., vocabulary) constructs, enabling accessible and user-friendly interaction with the VIT.	**DF4.1:** Consistent modular VIT structure. **DF4.2:** No overlapping design elements.
DP5: Domain-specific needs	M1, M4	Provide functions for customizing the VIT to fit specific ecosystem contexts, enabling users to adapt the VIT to their unique environmental and organizational needs.	**DF5.1:** Customizable white-label building blocks and elements. DF5.2: Flexible number of actors.
DP6: Conflict management	MR5	Provide functions for identifying and addressing conflicting interests or perspectives, enabling users to negotiate and gain shared understanding.	**DF6.1:** Visual markers for conflicts of interest. **DF6.2:** Tracking of reasoning and user labeling options. **DF6.3:** Repository for unresolved issues.

4.4 Evaluation of Initial Design Knowledge by Experts

The expert interviews lasted 61 minutes on average and were primarily conducted digitally (only two interviews were conducted face to face) in January 2025, with the consent of the interviewees to audio recording, if possible. At the beginning of each interview, the experts were introduced to the general research topic, the nine VITs, and the evaluation procedure.

Quantitative evaluation: The first objective of the expert interviews was to examine the initial design principles and design features on a quantitative scale. Hence, each expert provided quantitative feedback on the six design principles, rating them according to the five criteria of Iivari et al. (2021) on a five-point Likert scale (1 – very low to 5 – very high). Table 3 summarizes the quantitative evaluation of the 16 experts, presented by their status as practitioner or researcher.

The quantitative evaluation offers a nuanced overview of the experts' assessment. Overall, the results indicate a high level of endorsement across most criteria, particularly for accessibility (average = 4.3) and importance (average = 4.1), suggesting that the design principles and features are broadly seen as understandable and relevant by researchers and practitioners alike. Among the principles, **DP2** (accessibility) stands out with the highest total rating for accessibility (4.8) and actability (4.3), reflecting its ease of comprehension and practical applicability. Similarly, **DP4** (modularity) received a high rating for accessibility (4.5) and actability (3.9), and the highest rating for effectiveness among researchers (4.6), underscoring its perceived potential to enhance ecosystem design.

Conversely, the criteria of novelty showed lower scores across all principles (average = 3.2), with **DP1** (unified understanding) and **DP2** (accessibility) scoring particularly low (2.8 and 2.4 respectively), especially among practitioners. This suggests that, while these design principles are considered important, they are more likely to capture and contextualize established knowledge than to propose completely new ideas. Nevertheless, **DP6** (conflict management) emerged as the most novel design principle (3.9 total), and was particularly valued by practitioners as effective (4.3). **DP5** (domain-specific needs) was evaluated as least important (3.8), actable (3.5), and effective (3.4) because customization to specific contexts may lead to increased cognitive load and undesirable consequences such as misuse.

Interestingly, across most criteria, the researchers rated nearly all principles slightly higher than the practitioners, particularly in terms of importance and effectiveness, which may be due to their greater familiarity with design principles. In sum, the quantitative evaluation confirms the relevance and general reusability of the proposed design knowledge, while also indicating areas where further refinement would be beneficial.

Table 5. Expert Evaluation of Design Principles (based on Iivari et al., 2021)

Design Principle	Accessibility			Importance			Novelty			Actability			Effectiveness		
T=Total; R=Researcher; P=Practitioner	T	R	P	T	R	P	T	R	P	T	R	P	T	R	P
DP1: Unified understanding	4.2	4.3	4.1	4.6	5.0	4.1	2.8	3.3	2.4	3.9	4.1	3.7	3.9	4.0	3.9
DP2: Accessibility	4.8	4.9	4.6	4.1	4.5	3.8	2.4	2.4	2.4	4.3	4.8	3.9	3.6	3.7	3.5
DP3: Iteration and reflection	3.5	3.5	3.7	3.9	4.0	3.7	3.4	3.4	3.1	3.8	3.3	4.3	3.9	3.6	4.1
DP4: Modularity	4.5	4.6	4.4	4.2	4.6	3.7	3.4	3.9	3.0	3.9	3.8	4.0	4.1	4.6	3.7
DP5: Domain-specific needs	4.3	4.8	3.7	3.8	4.1	3.3	3.6	3.6	3.6	3.5	4.0	2.9	3.4	3.4	3.4
DP6: Conflict management	4.3	4.4	4.1	4.3	4.3	4.5	3.9	3.9	4.0	3.6	3.6	3.4	4.1	3.7	4.3
Average of all six DP	4.3	4.4	4.1	4.1	4.4	3.8	3.2	3.4	3.1	3.8	3.9	3.7	3.8	3.8	3.8

Legend: 1=very low, 5=very high. Note: Deviations of more than 10% of the average off all design principles are marked in green (positive) or red (negative).

Qualitative Evaluation: The second objective of the expert evaluation was to gain deeper insights into why a particular design principle and its respective design features were given mediocre ratings, especially in terms of accessibility, actability, and effectiveness. Hence, the experts were asked to give qualitative feedback on their quantitative decision. Understanding the reasons behind their evaluation allows to spot potential opportunities for improvement. The qualitative data were derived from notes taken during the interviews, and the transcribed recordings were analyzed through coding. The coding (top-down approach) of the transcriptions was divided into statements on each initial design principle and its respective design features, as well as general feedback on all the principles. In the following, I present the main insights from the interview analysis for each initial design principle, and some illustrative quotes[3].

DP1 (unified understanding) was rated on average as very important because the experts had experienced themselves the issue of not having a shared understanding during ecosystem design workshops: "I think this is definitely one of the key issues for ecosystem collaboration in general." (R3). By contrast, based on knowledge from other research areas, the general novelty of this principle was evaluated as relatively low: "In requirements engineering, a common understanding is often something that is actually a core principle" (R6). The idea of having specific features to address this issue was seen as somehow innovative: "How can we ensure that a shared understanding has actually been achieved and that this can be verified in some way using certain functions […]? I think this is a really important option to consider." (R4). However, regarding actability and effectiveness, the experts mentioned the limited time available in design workshops:

> The problem is that when you open up a dynamic glossary [DF1.2] or the checkpoints [DF1.1] […] in practice you effectively have half a day, or a day, whatever, in any case, a fixed period of time […] and [in so doing] you allow for the discussion to drift off. (P7)

The impatience of some users was also mentioned: "You know, it might be frustrating for some people, like, why are we talking about these terminology issues when we want to get to this actual real thing?" (R3). These experts seem to suggest, then, that it is preferable to avoid getting distracted by including too many features and, instead, focus on the task in hand, i.e., designing the ecosystem, and using the VIT to highlight that different understandings may exist, which could be addressed later on. In addition, experts mentioned improvements for accessibility of

[3] 14 interviews were conducted in German. The quotes have been translated into English.

DP1 due to vague terms: “I don’t really understand this dynamic glossary yet, especially the dynamic.” (R7).

DP2 (accessibility) was deemed essential, especially for users less familiar with ecosystem design: “I think this accessibility is very important for people who are perhaps not so familiar with the subject” (R6). Novelty, however, was rated as low because some experts consider it more to be general design knowledge: “This goes back to knowledge management, which I don't know, maybe from the 1980s, that it is really old coffee, that you learn well from examples. […] and that you should use pictures.” (R8). While DP2 was generally understandable, the experts suggested further specifications to be made to the ecosystem context to improve its actability, and mentioned a trade-off needed between accessibility and the level of details addressed: “If everything and every term has to be explained, then I believe that the effectiveness would be low, because I think it would overwhelm the tool.” (R6). In addition, several experts mentioned the importance of high-contrast designs for the improved accessibility of VITs.

DP3 (iteration and reflection) was generally understandable. Still, some experts noted that the naming is unclear, and that reflection could lead to potential misunderstandings: “Reflection, for me, means sitting down together afterwards and discussing what has been achieved.” (R8). In terms of importance, DP3 was considered highly relevant for ecosystem design: “The exciting thing about these tools is the process, it’s about generating ideas, ‘how did you come up with that?’, ‘what thoughts did you have?’, not just about the end result.” (R1). However, DP3 was discussed intensively in terms of actability and effectiveness. On the one hand, the experts mentioned vague guidance on how to concretely instantiate the features, and suggested, for example, using QR codes for tracking analog versions. On the other hand, DF3.2 (reflection questions) could lead to less effective workshops in terms of concrete outputs: “[this] is of course also very much a question of time restrictions, often, in some collaboration projects, for example, that you don't really have time to revisit [the output].” (R3).

DP4 (modularity) was not evaluated as completely novel because modular VITs already exist, especially in relation to the BMC and Value Proposition Canvas. Yet, the importance for ecosystem design was seen as high, for example, due to similar experiences when developing VIT: “We developed a business model canvas for Gaia X, and actually found it very challenging to work with a single canvas for a long time because it essentially overloaded the user cognitively.” (R7). However, in terms of accessibility some experts mentioned difficulties due to imprecise terminology: “In that case, you'll have to explain to me again exactly what you mean by modules.” (P3) which also resulted in challenges for perceived actability: “I mean, these is, I think, an important design principle, but from the features here I would not know myself how to put it together.” (R3). Therefore, the experts suggested further concretization of the design features based on structural elements, for example, as suggested by P8:

> Step 1, I only see the partners; step 2, I only see the ones I don't know, the NGOs I need; or step 4 is just the customers, and step 5 is just the interaction, so that you get a level model, but basically adaptivity. (P8)

In terms of effectiveness, the number of instantiated modules could also present a challenge: “I think maybe somewhere, in one of the features, reflect the idea that even if you have modular things, you don't want to have too many of them. […] I mean it defeats the purpose.” (R5).

DP5 (domain-specific context) was the principle with the lowest quantitative evaluation and attracted the most criticism in the discussions. While DF5.2 (flexible number of actors) was seen as highly relevant, DF5.2 (customizable sections) was considered as potentially detrimental: “Well, I'm not sure about that. The idea is good, but how can I put it…. the beauty of these frameworks is precisely that they limit and focus your thoughts. Otherwise, you wouldn't need a framework, you could just [do a] brainstorm [session]." (P3). In particular, the experts found the implementation of customizable sections to be a drawback:

> But of course, you could also say, well, one box is probably not enough. Let's add another five empty boxes next to it so that it can be customized, because there's no right or wrong answer, and that's why I'm struggling to figure out how to actually put this into practice. (P4)

This problem was also discussed and it was argued that it could lead to ill-considered VIT extensions: "I'm a bit skeptical about that. Because it invites people to mess around with existing tools and somehow come up with a new field without having any idea what they're doing." (R8). In addition, the term "domain" was seen as too vague: "I would like to understand what a domain is. […] When I think of domain, it can mean a lot of things" (P1).

DP6 (conflict management) was evaluated as particularly novel and effective: "If you plan for this, the solutions [outcomes] are better, even if they take longer." (P5). However, some experts criticized the naming of the principle. The term conflict was seen as having too many negative connotations:

> I don't know if conflict management is the right term. Or whether it's just a point open to discussion, because when I hear the word conflict, I immediately think of real conflict, interpersonal conflict, even if sometimes it's just a difference in understanding or opinion. (P7)

On the other hand, the term management was not seen as suitable either:

> I like the color coding when you're flagging up something, where there's like a problem or a conflict. But I don't know if [using] the visual inquiry tool is the [right] place to resolve the conflict. […] How far do you take the process of resolving conflicts? (R5)

At the same time, it was pointed out that the proposed features are not really helpful for managing conflicts. Yet, the experts suggested broadening the definition of conflicts, including actor dependencies: “Is it possible to broaden the scope of the conflict a little? Sometimes it’s enough just to point out dependencies” (P6), and to focus the principle on awareness:

> That means, I could imagine that you would first create awareness, because as a tool designer, I would want the tool to tell me, “Hey colleague, there’s a potential problem here,” because I might not notice it myself, and secondly, I would check it out [and] want to solve it. It does sound a bit to me as if that’s already the solution, but I find [creating] this awareness far more exciting. (P1)

The **general feedback** regarding all six design principles addressed two main topics. First, the experts mentioned a general tension between efficiency and effectiveness of the VITs for ecosystem design. In terms of efficiency, VITs should enable the design of an ecosystem within a fixed and limited timeframe, while simultaneously producing an acceptable output, given the often tight time schedules of users (e.g., managers, consultants) of the various organizations involved. In terms of effectiveness, VITs should enable the design of well-considered ecosystems that provide concrete value for future prototyping. While DP2 (accessibility) may increase both efficiency and effectiveness, other design principles, such as DP1 (unified understanding) or DP6 (conflict management) may increase effectiveness, but at the cost of decreasing efficiency. Second, the experts asked for further guidance for the concrete instantiation of design features in analog settings (i.e., paper-based posters) or through software support. While both options are encompassed by the VIT design theory of Avdiji et al. (2020), the concrete design feature instantiation could vary if additionally supported by software.

5 Final, Revised Design Principles and Design Features

Table 6 summarizes the accumulated design knowledge obtained in this study by outlining the final set of design principles and design features. In addition, it shows the (potential) benefits of using software for instantiating each of the individual design features (following Schoormann et al., 2021).

Based on the qualitative feedback, I refined the initially proposed design knowledge (see Table 4), with slight changes made to the wording of the principles and features, to render them more comprehensible and effective for tool creators (i.e., researchers and practitioners). The most significant revisions in terms of amendments were made to DP1, DP5 and DP6. The first design principle, DP1 is now referred to as mutual understanding and focuses on raising awareness that different understandings can coexist. To avoid compromising the efficiency of the VITs, rather than assuming or enforcing a unified understanding, different understandings co-exist but can be flagged up in the VIT (DF1.1) and further described in an interactive glossary (DF1.2). DP5 was revised entirely due to the mostly critical expert feedback regarding customizable tools. Accordingly, DF5.2 (customizable sections) has been deleted, while DP5 now focuses on actor adaptability (i.e., functions to adjust the varying number of ecosystem actors). Finally, I revised DP6 to allow for the trade-off between efficiency and effectiveness, and to be able to highlight the various actors' viewpoints—hence its new title, various viewpoints—which users could address at a later stage, if they so wish or if circumstances require it.

Table 6. Final Set of Design Principles and Design Features

Design principles	Design features	(Potential) benefits of using software support
DP1: Mutual Understanding		
Provide functions for detecting different interpretations of key concepts and terms, allowing users to observe and compare different understandings.	**DF1.1:** Provide visual markers (e.g., color codes, flags, or symbols) for comprehension checks that users can employ if they become aware of different understandings. **DF1.2:** Provide an interactive glossary space where users can describe their current understandings of key concepts and terms.	**DF1.1.:** Visual markers can be applied in analog and digital versions. **DF1.2:** Software allows for extending and refining the glossary and offers the possibility of referencing external sources.
DP2: Accessibility		
Provide functions for improving intuitive comprehensibility by reducing cognitive load, enabling users to orient themselves quickly and interact with the VIT immediately.	**DF2.1:** Incorporate icons and symbols that reflect commonly understood meanings in the ecosystem context. **DF2.2:** Offer brief, easy-to-understand explanations and guidelines that are accessible through links in the VIT. **DF2.3:** Present concrete, annotated examples that show how each VIT element can be applied in real-world ecosystem design settings. **DF2.4:** Use high-contrast colours and clear visual separation to ensure that key elements are easily distinguishable by all users, including those with visual impairments.	**DF2.1:** Icons and symbols can be applied in analog and digital versions. **DF2.2:** Software offers the possibility of integrating hyperlinks. **DF2.3:** Software can integrate multiple examples more easily. **DF2.4:** High-contrast design can be applied in analog and digital versions.
DP3: Iterative Development		
Provide functions for revising and building upon previous versions of the ecosystem design, enabling users to iteratively improve the design over time and reflect on contextual shifts across iterations.	**DF3.1:** Provide intuitive version control with metadata (e.g., timestamps, participants, change notes) to transparently document progress and enable users to revisit or reuse earlier versions. **DF3.2:** Include a dedicated visual space for capturing key takeaways after each iteration, helping users document learnings and follow-up actions **DF3.3:** Provide simple and predefined reflection questions, prompting users to reassess their input quickly.	**DF3.1:** Software allows for automatic version control without any extra effort. **DF3.2:** Software allows for extending and refining the dedicated visual space. **DF3.3:** Reflection questions can be applied in analog and digital versions.

DP4: Modularity		
Provide functions for structuring the VIT in modular, cognitively manageable components to reduce visual complexity, enabling users to design ecosystem elements incrementally and from multiple perspectives.	**DF4.1:** Provide a layered modular structure to design the structural elements of ecosystems (i.e., value proposition, activities, actors, positions, links) in a stepwise fashion. **DF4.2:** Minimize visual clutter in each design module. **DF4.3:** Enable consolidation of modules into a holistic ecosystem design view.	**DF4.1:** A modular structure can be applied in analog and digital versions, while software allows for easy switching between them. **DF4.2:** Software allows for minimizing visual clutter by hiding visual elements. **DF4.3:** Software offers the possibility of zooming out and connecting design modules.
DP5: Actor Adaptability		
Provide functions for tailoring to specific ecosystem actor requirements, enabling users to adjust the VIT to suit a varying number of actors.	**DF5.1:** Enable the VIT to scale for ecosystems of varying actor sizes.	**DF5.1:** A varying number of actors can be applied in analog and digital versions, while software makes adjusting the numbers more easily.
DP6: Various Viewpoints		
Provide functions for highlighting varying actor viewpoints, enabling users to raise awareness of different perspectives and potential ecosystem tensions.	**DF6.1:** Provide visual markers (e.g., color codes, flags, or symbols) to highlight varying viewpoints of ecosystem actors. **DF6.2:** Enable users to document key ecosystem design decisions through recording comments. **DF6.3:** Offer a dedicated visual space for unresolved, varying viewpoints.	**DF6.1:** Visual markers can be applied in analog and digital versions. **DF6.2:** Software allows for commenting on design decisions without visual clutter. **DF6.3:** Software allows for extending and refining the dedicated visual space.

6 Discussion

Multi-actor ecosystem design is a highly collaborative process that aims to address complex innovation challenges and situations of uncertainty for business models across various industries. The success of such ecosystems is often compromised, however, by potential conflicts between actors about their respective strategies towards value creation and capture in the design stages of the system. Bearing in mind that information systems research has the necessary knowledge to enable "strategizing as designing" (Osterwalder and Pigneur, 2013), the discipline can offer appropriate tools and design knowledge, drawing on design science research, to help address this issue (Vom Brocke & Maedche, 2019).

My observational design science research approach involved far more than just information gathering, however. It followed a process of identifying, analyzing, comparing, and evaluating multiple VITs to derive an understanding of the existing solution space and salient unaddressed user requirements that can be translated into possible enhancement solutions (i.e., open up the solution space). This aligns with contemporary discussions among design science researchers that underscore the importance of collecting and reutilizing design knowledge more cumulatively (Vom Brocke, Winter, et al., 2020).

Aiming to address two research questions, the study uncovered several insights. First, the results from the systematic analysis of the nine identified VITs (stage 1 addressing RQ1) showed that VITs originate in various research areas, have used well-elaborated research methods, and thoroughly considered their theoretical underpinning to address different focus areas. However, these VITs do not always conform with the suggested design principles of the design theory for VITs (e.g., development of a conceptual model, non-parsimony use of elements). This criticism should be seen in the context of the date of publication of these VITs, some of which predate the proposal of a design theory for VITs. Moreover, considering the structural view on ecosystems (Adner, 2017), potential research opportunities may exist, for example, to address a lack of explicit functions to design ecosystem links and positions. Moreover, only a few identified VITs explicitly consider the ecosystem-as-structure view. Nevertheless, answering RQ1 was a necessary step to understand the existing solution space and to provide further design knowledge for its enhancement.

Second, the results from two workshops—a digital artifact-in-use workshop, and an analog workshop—exposed several cross-artifact collaboration challenges (e.g., different understandings of concepts, users struggled with cognitive overload, limited support for iteration, or for visibly flagging up conflicts of interest). Building on these insights, the study derived five meta-requirements and translated them into six design principles, each specified by concrete design features. Interviews with researchers and practitioners confirmed the importance, actability, and effectiveness of these design principles and features, particularly emphasizing the importance of functions that enable mutual understanding (DP1) and various actor viewpoints (DP6). Together, the final set of six design principles and sixteen design features provides actionable, evidence-based guidance for tool creators, and, additionally, presents a nascent design theory that provides the foundation for advancing VITs, which enable the effective joint exploration of multi-actors' ecosystem ambitions.

6.1 How the Study's Design Knowledge Relates to the Design Theory for VITs

The design theory for VITs (Avdiji et al., 2020) presents an essential step in design knowledge for creating VITs with a high projectability (i.e., it can be used to design VITs for all kinds of management problems). For tool creators, it provides guidance on crucial aspects for designing effective VITs (e.g., the development of a conceptual model). However, this high projectability comes at a trade-off, namely, the relatively low fitness for specific problem domains (see Figure 5, arrow A). Hence, the design theory for VITs does not provide concrete advice on how tool creators ought to operationalize the proposed design principles of the design theory for VITs (Roschnik & Missonier, 2023).

To address this challenge, this study contributes a contextualization of and extension to the design theory for VIT, aiming to achieve a medium fitness for a specific class of VITs, although at the cost of lowering projectability (see Figure 5, arrow B). In other words, I explored and revised a set of design principles for VITs suitable to supporting the design of multi-actor ecosystems, and concrete guidance for how the design principles can be instantiated through design features.

Nevertheless, through my inductive approach and the fact that the three selected VITs for the workshops did not consider all the design principles of the design theory (e.g., the use of visual arrangements described in DP2.3 – Facilitation), the derived design knowledge of this study partly overlaps with the design theory in two ways. First, it also identified the use of icons and symbols (DF2.1) as relevant design knowledge. In this way, this study underlines the importance of DP2.3 – Facilitation in the design theory of VITs. Furthermore, it contextualizes it for the context of multi-actor ecosystem design by providing more detailed guidance for its instantiation.

Second, the design theory suggests the use of a parsimonious number of components for the conceptual model (DP1.3 of the design theory for VITs). The user feedback analysis conducted in this study confirmed the importance of this principle, as many students encountered cognitive overload. However, ecosystem design is inherently very complex as it must take several actors into account. Therefore, DP4 (modularity) contextualizes the DP1.3 (Parsimony) of the design theory for VITs by suggesting the use of a modular structure for shared visualization. In summary, this study contributes to the design theory for VITs by addressing the high projectability and lack of detailed instructions for concrete instantiations by highlighting their relevance and by contextualizing further design knowledge for a specific problem domain. Tool creators should therefore consider both the design theory for VITs, and the design knowledge proposed in this study when creating VITs for multi-actor ecosystem design.

6.2 How the Study's Design Knowledge Relates to Adjacent Literature

This study is based on an inductive theorizing approach and, therefore, limited in its theoretical grounding (Gregory and Muntermann, 2011). While related design knowledge from the literature on visual inquiry and business model development tools (mainly building on the BMC) could be identified (see chapter 2.2), their transferability is limited because they do not relate to cross-organizational contexts. Hence, this study presents novel design knowledge for VIT design in the form of contextualization to multi-actor ecosystems. However, as mentioned by several experts, the design knowledge is not entirely novel in its individual design principles.

For example, concerning the proposed DP1 (mutual understanding), seminal work on cultivating shared understanding in collaborative work environments has been presented by Bittner and Leimeister (2014). This study advanced the discourse on the phenomenon of shared understanding and its formation, underscoring its importance even within one large manufacturing company. In light of this, Bittner and Leimeister (2014), and further studies on integrating differing understandings (e.g., Vlaar et al., 2006), offer a fertile ground for comparison and theoretical grounding of DP1. Additionally, Bittner and Leimeister (2014) build on collaborative engineering, which is a topic that has been discussed in the information systems literature for quite some time (Vreede et al., 2009). This literature strand could offer a source for further investigations toward the instantiation and testing of the design knowledge with software support. Consequently, the information systems literature provides several starting points for further developing and testing the design knowledge gained in this study, and integrating it into the respective knowledge base.

6.3 Limitations

Due to its exploratory nature, and in common with design science research in general (Barata et al., 2023), this study is not without limitations. The first limitation is the focus on research artifacts published in established journals (VHB Ranking 2024 ≥ C). On the one hand, VITs are often presented first at conferences and published in the proceedings. On the other hand, practitioners such as large consultancies have also developed several VITs, which could contribute interesting additional artifacts for analysis. However, practitioner tools are rarely freely available. In this way, this paper provides an overview of only a subset of relevant artifacts in the solution space that can be analyzed through scientific publications.

A second limitation is that the artifact-in-use workshop (stage 2) was conducted with students, digitally, without a direct facilitator, with limited time for the use of VITs. While the students were trained to use other VITs and *Miro* beforehand to ensure an efficient ecosystem design workshop without technical issues, VITs for ecosystem design are typically used over a longer timeframe. In addition, while the students were enrolled in different study disciplines, they did not represent stakeholders from different organizations. Students, therefore, cannot fully mirror the challenge of cross-organizational workshops. The artifact-in-use workshop aimed to create an optimal artificial environment for such a setting, but despite all the efforts made, a high level of confidence cannot be claimed (Vom Brocke, Winter, et al., 2020). Yet, I argue that if the observed collaboration challenges arise even among trained students, they are very likely to arise in real-life ecosystem design workshops, too.

A third limitation is the inductive way in which the meta-requirements are derived and then translated into design principles and design features, which is based on one person's (the author's) subjective decisions. Although I grounded the design decisions in the analysis of existing VITs and in salient user requirements, some of these principles may be instantiated through other functions that are not considered in this study. For example, while I derived the principle of structuring the VIT in modular, cognitively manageable components to reduce visual complexity (DP4), others might prefer different solutions to reduce the complexity of ecosystem design. Moreover, while some researchers argue that an inductive approach has multiple advantages for theory building in management and adjunct disciplines (Locke, 2007), a deductive approach may result in design knowledge addressing specific design issues (e.g., Schoormann et al., 2023). Therefore, this study does not make the claim that the proposed design knowledge solves all collaboration issues entirely.

6.4 Opportunities for Future Research

Aiming to propose future research opportunities that do not merely address the study's research limitations (Barata et al., 2023), I build on the editorial of vom Brocke and colleagues (2020) and map potential further design knowledge movements. In this way, the study provides a potential point of leverage for future research and for the further development of VIT design knowledge in a cumulative fashion and as a discipline in its own right. For future research, I see three potential paths to further accumulate design knowledge.

The first path is aimed at *generalizing* (i.e., to obtain a higher projectability with constant fitness) the proposed design knowledge (nascent design theory) of VITs for multi-actor ecosystem design into a mid-range design theory for VITs projected onto a wider problem space (see Figure 5, arrow C). This extended problem space could address other cross-organizational design challenges, such as data sharing, where VITs have already been proposed (e.g., Geppert et al., 2025). While the results of this study are based on the investigation of VITs in the substantive context of multi-actor ecosystem design with a business model perspective, I suggest that they might be applicable to a broader set of contexts of cross-organizational collaborations, and thus for a wider class of VITs that could be achieved by generalizing the proposed design knowledge into a design theory.

The second path is aimed at *amplifying* (i.e., higher fitness with constant projectability) the design knowledge by increasing the level of detail of the solution space while still addressing the problem space of multi-actor ecosystem design (see Figure 5, arrow D). This could be achieved through instantiating the design knowledge into a software artifact, such as the proposed co.Lab platform (Roschnik et al., 2024). Moreover, many experts mentioned the possibility of leveraging artificial intelligence (AI) for implementing the design features. AI could, for example, support DF1.2. (interactive glossary) by proposing definitions.

The third path is aimed at further *contextualizing* (i.e., higher fitness with lower projectability) the design knowledge and investigating individual VITs—for example, the Boundary Tool (Velter et al., 2022)—in real-world ecosystem design settings, addressing the challenge of circularity (see Figure 5, arrow E). In such specific contexts, an avenue for research is to explicitly address the trade-off between efficiency and effectiveness in both analog and digital settings, which is likely to be difficult to generalize to a broad class of problems. This would also address the second limitation of this study (artificial environment) and produce design knowledge with higher confidence.

Apart from these future developments in design knowledge accumulation, and in line with other researchers, such as Avdiji et al. (2020) or Molla et al. (2024), I see further research opportunities for providing more methodological guidance for conducting observational design science research projects. The lack of methodological guidance for conducting such projects led to many methodological pivots during the study and to numerous justifications in this manuscript. More methodological guidance would be welcome to fill this gap.

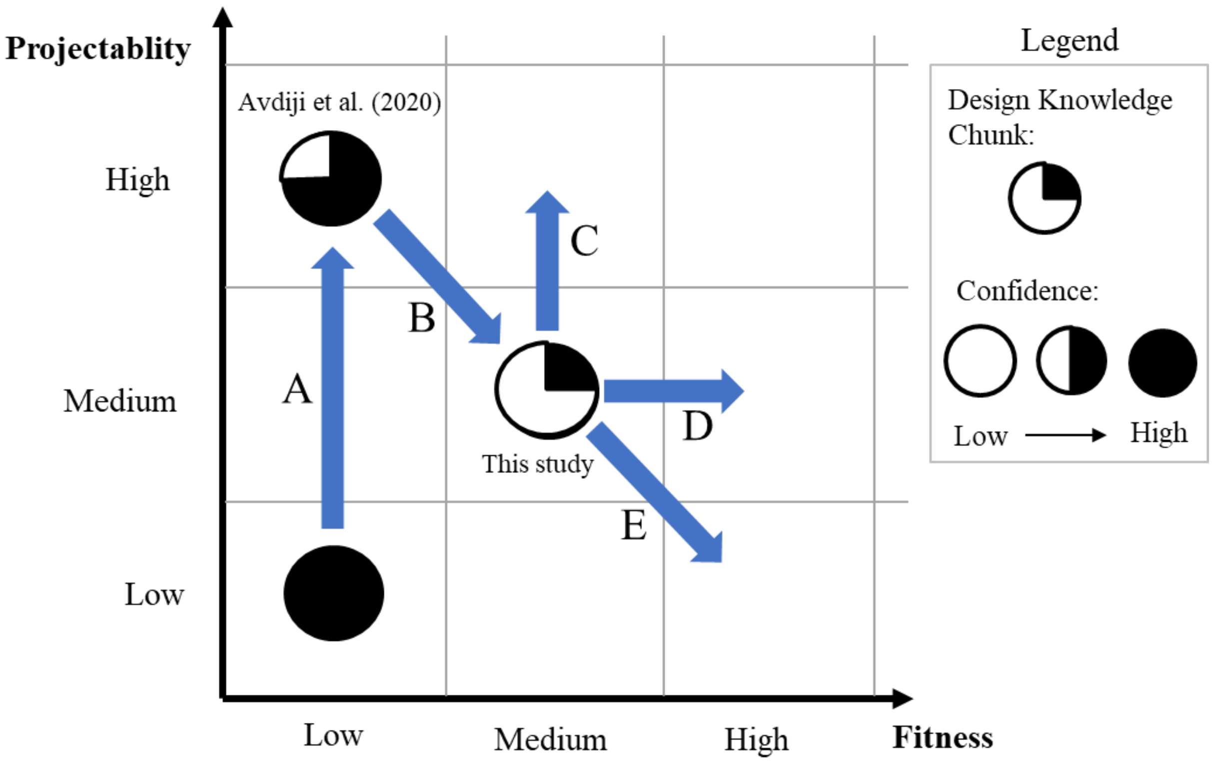

Figure 5. Design Knowledge Movements for VITs

7 Conclusion and Contributions

This study aims to advance the understanding of how VITs can be enhanced to better support the design of multi-actor ecosystems—an increasingly critical endeavor in a world where innovation depends on the ability of organizations to collaboratively create and capture value across industry boundaries. I conducted an observational design science research study informed by ideas from the design archaeology approach (Chandra Kruse et al. 2019). By systematically identifying and analyzing nine existing VITs, I revealed both the interest in and endeavors of various research areas on this topic, as well as the shortcomings that continue to exist, particularly in terms of accumulated and leveraged design knowledge. Additionally, the study evaluated the tools-in-use. Based on that, I derived six design principles and associated features, and further refined them with the help of experts. By doing so, I participate in the accumulation of prescriptive design knowledge for VITs (vom Brocke et al., 2020) and contribute to research and practice in several ways.

First, I identified and analyzed the current landscape of VITs for multi-actor ecosystem design. This aggregates the scientific body of knowledge on VITs. By identifying nine VITs published in established academic journals, I provide a foundation that enables researchers to build upon existing approaches and identify potential research gaps that were previously scattered across various research areas. In addition, the results are already of interest to researchers and practitioners, who can now identify and choose appropriate VITs for their ecosystem projects.

Second, and most importantly, I extend the literature on design knowledge and advanced functionalities for VITs. This design knowledge was evaluated by 16 experts based on established criteria, thereby providing a solid foundation for further research. Therefore, the contributions of this study could offer a first step toward the maturation of this increasingly important research area of VITs, and offer researchers aiming to build distinct software for VITs a potential instantiation use case (Roschnik, 2024). In the long term, the research area of VITs could be on an equal footing with the research area of conceptual modeling.

Third, the evaluated design knowledge is also of great value for practitioners. For example, large consultancy firms that offer support for multi-actor ecosystem design often develop their own VITs and could consider the proposed design knowledge for redesigning their tools. Additionally, the findings may be relevant to collaborative online whiteboard platforms such as *Miro* or *Mural*, seeking to expand their collaborative features.

Fourth, I discuss and present possible journeys of further design science knowledge accumulation in the area of VITs for the information systems community. This brings coherence and direction to the fast-growing body of literature on design support for VITs that will help to create new features, redesign existing tools, or design entirely new tools.

In conclusion, this study connects the current state of VITs for multi-actor ecosystem design with empirically grounded prescriptive design knowledge to enhance their effectiveness. In this way, the study provides a potential leverage point for future research and VIT enhancement studies, conducted more cumulatively, and as a possible research area in its own right. I hope that by offering detailed guidance to tool creators, they will be better equipped to develop VITs that support ecosystem design in practice, potentially leading to a collaborative and sustainable tomorrow.

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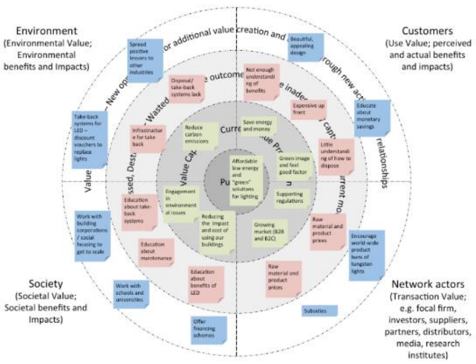
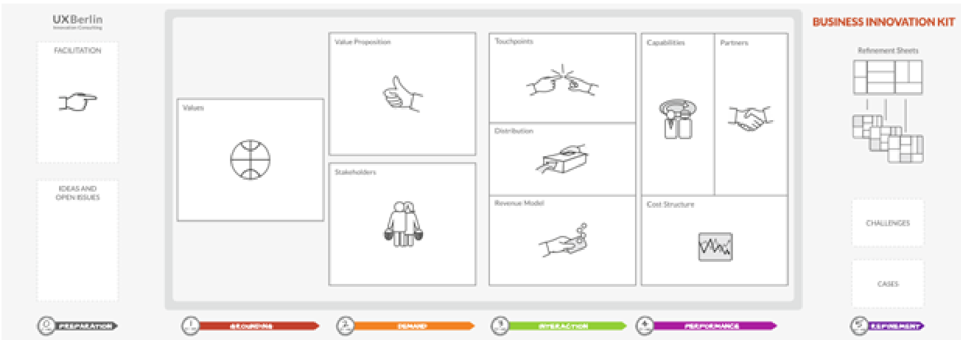
Appendix

#1 (Bocken et al., 2013)

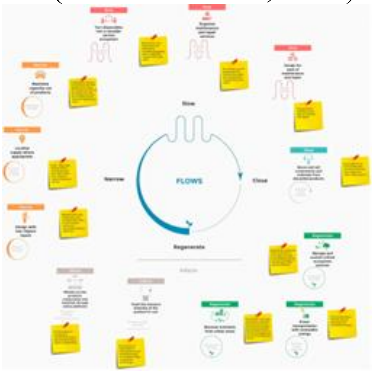


#3 (Turetken et al., 2019)

#2 (Breuer & Lüdeke-Freund, 2017)

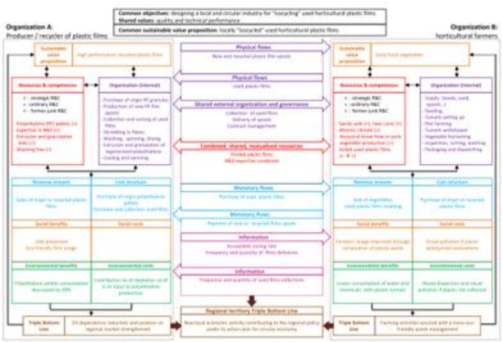


#4 (Konietzko et al., 2020)



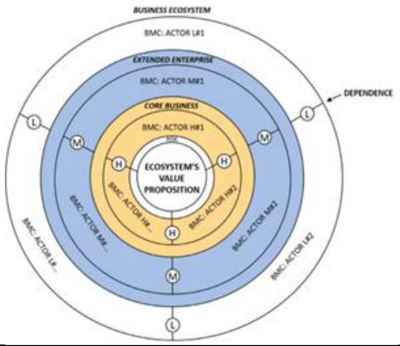
#5 (Talmar et al., 2020)

#6 (Boldrini & Antheaume, 2021)



#7 (Velter et al., 2022)

#8 (Goncearuc et al., 2022)



#9 (Jütting, 2024)

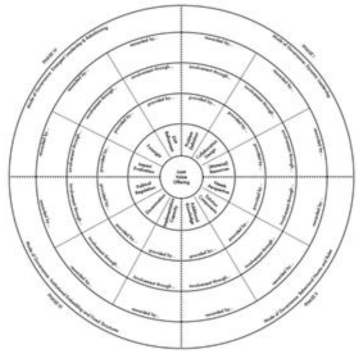


Figure A1. Visual Inquiry Tools for Multi-Actor Ecosystem Design in Academic Sources

Table A2. Short Description of the Design Principles of Avdiji et al. (2020)

Design Principle	Short Description
DP 1 – Conceptual Model	Build a conceptual model.
DP1.1 – Frame	Develop a conceptual model of the design problem with mutually exclusive and collectively exhaustive components.
DP1.2 – Rigor & Relevance	Build the conceptual model on academic justificatory knowledge.
DP1.3 – Parsimony	Keep the conceptual model parsimonious.
DP2 – Shared Visualization	Build a shared visualization.
DP2.1 – Functionality	Instantiate the conceptual model into a shared visualization represented as empty problem spaces.
DP2.2 – Arrangement	Arrange the components of the shared visualization according to their relationship in the conceptual model.
DP2.3 – Facilitation	Use simple common language as well as appropriate images or metaphors.
DP3 – Directions for use	Define a set of directions for use through techniques that allow for …
DP3.1 – Ideation	Ideation,
DP3.2 – Prototyping	Prototyping,
DP3.3 – Presentation	Presentation.

Table A3. Open-Ended VIT Evaluation Questions after the Digital Artifact-in-use Workshop (based on the Testable Propositions of Avdiji et al. (2020))

Testable propositions (TP)	Explanation of Testable Proposition	Open-ended question for user feedback after the digital artifact-in-use workshop
TP1 – Efficacy	The use of the visual inquiry tool supports and improves the outcomes of a process of joint inquiry into a strategic management problem.	**Question 1** (Intention to use): What are the advantages of using the tool again (compared to other approaches), and what are the disadvantages? **Question 2:** (Perceived Creativity): What stimulated your creative thinking?
TP2 – Effectiveness	The visual inquiry tool can be successfully used by individuals and groups within the context of the particular managerial problem and organizational context for which it was designed.	**Question 3:** Did you experience the provided tool as useful or not useful? In particular, what advantages or problems could arise when communicating the designed business models?
TP3 – Efficiency	The use of the visual inquiry tool does not require an inappropriate amount of time or other resources	**Question 4:** Was the tool easy to understand? If not, why did it take long to use it effectively?
TP4 – Elegance (Aesthetics)	The shared visualization in the tool is easy to understand and use.	**Question 5:** Was the provided tool easy to use? If not, why was it difficult to understand, or what comprehension issues arose? **Question 6:** Which of the concepts, terms or wording in the provided tool were unclear?
TP5 – Ethicality	Participants in the inquiry using the tool are not disadvantaged by the outcomes of the joint inquiry compared to other participants, nor are they injured or stressed in the joint inquiry process.	-
Final questions (not related to the testable propositions)		**Question 7:** What are the general strengths of the tool provided? **Question 8:** What are the general weaknesses of the tool provided?

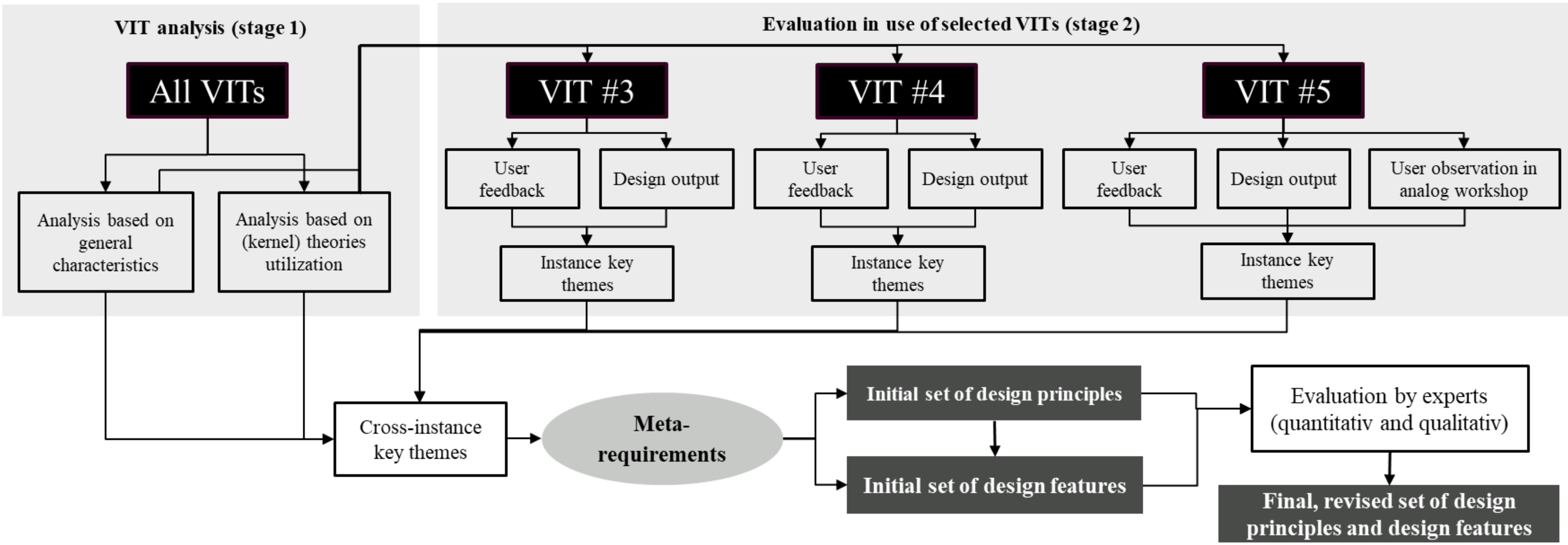


Figure A4. Data Analysis and Design Knowledge Derivation Procedure

Table A5. Overview of Expert Interview Participants

ID	Category	Gender	Education	Region	Working position	Industry	Interview length
R1	Researcher	Male	Ph.D.	Germany	Manager of professional education program	Research and innovation network	97:23 min
R2	Researcher	Male	Ph.D.	Germany	Postdoc	University	75:45 min
R3	Researcher	Female	Ph.D.	Finland	Postdoc	University	49:08 min
R4	Researcher	Male	Ph.D.	Germany	Postdoc	University	51:08 min
R5	Researcher	Female	Ph.D.	Switzerland	Postdoc	University	68:40 min
R6	Researcher	Male	M.Sc.	Germany	Project manager and Ph.D. student	Applied research	62:41 min
R7	Researcher	Male	Ph.D.	Germany	Senior engineer	Applied research	56:03 min
R8	Researcher	Male	Ph.D.	Germany	Postdoc	University	92:12 min
P1	Practitioner	Male	Ph.D.	USA	Manager business consulting	Consulting	57:02 min
P2	Practitioner	Male	M.Sc.	Germany	Assistant to the managing director	Electric mobility	42:12 min
P3	Practitioner	Male	Ph.D.	Germany	Business strategy manager	Consulting	56:14 min
P4	Practitioner	Male	Ph.D.	Germany	Innovation manger	Energy	98:02 min
P5	Practitioner	Female	Ph.D.	Germany	Senior project manager	Banking	32:34 min
P6	Practitioner	Male	Prof.	Germany	Head of digital customer experience management	Consulting	30:55 min
P7	Practitioner	Male	M.Sc.	Germany	Manager business consulting	Consulting	49:42 min
P8	Practitioner	Male	M.Sc.	Germany	Manager business consulting	Consulting	52:56 min