'License to VIT' - A Design Taxonomy for Visual Inquiry Tools

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Abstract

Visual Inquiry Tools are valuable assets to work conjointly on an ill-structured or wicked problem and solve it creatively. With visual inquiry tools, designers can sketch the problem-space of an artifact-to-be-designed and generate solutions in a priori defined ontological elements. While there exists guidance in how visual inquiry tools should be designed content-wise, there is a lack of clarification on the design options available to design them. Subsequently, the paper proposes a taxonomy of visual inquiry tools outlining options for their design. We do this by incorporating a sample of 24 visual inquiry tools developed in the scientific literature corpus and 15 empirical examples.

1. Introduction

Visual Inquiry Tools (VIT) are collaborative tools that enable their users to work on ill-structured problems in a dedicated canvas-style *problem space* [1, 2]. Canvases are two-dimensional graphical illustrations that transfer complex issues into *mnemonics* through ontological decomposition [3, 4]. An ill-structured problem is a problem that lacks a clear definition and structure [5]. Beyond that, VITs (also called, e.g., *visual collaborative tools* [6], *innovation canvas* [4], or *design canvas* [7]) enable a shared understanding of problems and facilitate interdisciplinary problem-solving and creative design through visualization in settings with a lack of straightforward solutions [2, 4, 8, 9]. Their underlying flexibility and utility have led to VITs being used in a variety of diverse application domains. For example, scholars propose VITs in *design science research* (e.g., see [3, 7, 10, 11]), *data innovation* (e.g., see [6, 12]), *literature reviews* (e.g., see [13]), or *service innovation* (e.g., see [14–16]). Given the plethora of application domains and scenarios, we see an opportunity to structure the field of VIT design and strengthen the rigor and effectiveness of the artifact through a taxonomic approach [17]. Taxonomies have successfully enriched a variety of domains and assist researchers and practitioners in navigating the analysis and design of a specific artifact through design options (e.g., *digital twins* [18] or *business models* [19]).

In the past, the scientific rigor in developing VITs has frequently been critiqued [1, 4, 8]. For example, Avdiji et al. [8 p. 2] criticize that "(…) it is not clear how rigorously and theoretically sound these tools are designed". Given that an increasing number of these tools are published in peer-reviewed literature adhering to rigorous designs is paramount [4]. Currently, some guidelines support creating VITs (e.g., see [8]). For example, Avdiji et al. [1, 8] provide design principles integrated into a design theory that propose codified prescriptive design knowledge collected in three design projects for VITs. Correspondingly, Thoring et al. [4] outline morphological characteristics that include parameters about the number of elements VITs should consist of or the medium they should be offered in. Yet, both types of design guidance lack a processual view describing design options on why and how VITs should be created. Given the relevance of the VITs to design new artifacts creatively [3] and the above, we analyze how they are supposed to be created based on the existing literature corpus and the choices the designer has to make.

Subsequently, we strive to provide researchers and practitioners with *design options* for VITs that complement existing *design principles* [1, 8] and content-oriented *morphological characteristics* [4]. Given that VITs reduce the complexity of an object-to-be-designed by decomposing into intuitively understandable ontological elements, we can position it as a *model* following March & Smith's [20] categorization of artifacts [21]. They are potentially clearly arranged tools to map out existing and required *design knowledge* in design projects [3]. *Designing* a VIT is commonly done by following a *design science research* (DSR) method (e.g., [22]). Given its position as an *artifact* (i.e., a non-natural object with a human author and purpose [23]), designing them requires navigating potential design options that shape its final form, which can be seen as "(…) a game of combinatorics (…)" [24 p. 247]. Because of the above, our research question reads as follows: *What are the design options to develop visual inquiry tools?*

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For that purpose, we develop a taxonomy, which, if visualized morphologically, is the basis for deconstructing an artifact into design options in a structured manner [25]. We follow the method of Nickerson et al. [26] in three iterations and incorporate both conceptual and empirical objects through a systematic literature review [27] and *desk research*.

The paper is structured as follows: In the next section, we introduce the notion of VITs *en détail*. Section 3 explains our research method following a combinatorial approach of a systematic literature review [27] and the taxonomy design method of Nickerson et al. [26]. Section 4 illustrates our findings in the form of a morphological taxonomy, which we discuss in Section 5. Lastly, we highlight contributions, limitations, and potential avenues for further research.

2. Visual Inquiry Tools

As the name suggests, VITs enable their users to collaboratively and intuitively work in a demarcated and visualized *problem space* [1]. We will use the term VIT in the paper, even though there are synonyms (see Table 1). Perhaps the most famous example of a VIT is the *Business Model Canvas (BMC)*, which deconstructs business models into nine designable ontological elements [28, 29]. Generally, a VIT calls to deconstruct an artifact into 'building blocks' [8] that are supposed to be filled out and act as a checklist, reminding users of essential designable elements [3].

Table 1. Exemplary definitions of VITs.

Term	Definition
Visual Inquiry Tool	"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." [30 p. XV]
Design Canvas	"(…) a two-dimensional, poster-based tool that guides a heterogeneous team with a particular challenge or task". [4 p. 2]
Visual Collaboration Tool	"We define a visual collaboration tool as a co-creation tool that "enables and facilitates collaborative thinking, mapping, dreaming, and story" [16]"[1]

Figure 1 shows an exemplary graphical representation of the logic of VITs and corresponding 'building blocks' [8]. Each 'building block' is usually specified and 'filled out' using sticky notes. That allows information and ideas to be easily added, modified, and replaced in live settings and crystalize ideas and solutions that stick [4, 8]. For example, an ontological element of the BMC is the *value proposition*. Users of the tool need to fill in potential *products* or *services* that they wish to offer to a corresponding *customer segment* [28].

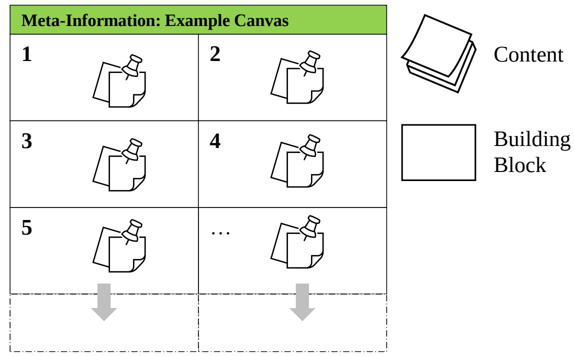

Figure 1. Exemplary graphical representation of how visual inquiry tools are built.

Avdiji et al. [8] propose a design theory for VITs based on the reflective analysis of three cases, i.e., the *Business Model Canvas* (BMC), the *Value Proposition Canvas* (VPC), and the *Team Alignment Map* (TAM). From these cases, they abstract a total of 12 design principles categorized into three areas, namely *Conceptual Model*, *Shared Visualization*, and *Directions for Use*. Though the design theory and the corresponding design principles address essential issues in designing a VIT, they do not address design options to construct the artifact.

Correspondingly, Thoring et al. [4] propose a *morphology of innovation canvases* that contains design choices for designing canvases on a very detailed content level. For example, the morphology includes dimensions as detailed as the number of elements that the canvas should have (ranging from 5-7 to more than 15 in a range of six morphological characteristics).

3. Research Design

Our artifact is a taxonomy. Thus, we use the *de facto* standard [32] in taxonomy design, i.e., the method of Nickerson et al. [26]. In the design cycles of applying the method, we opt for a *systematic literature review*. We do this to collect a representative sample of existing VITs, given that part of our objects of interest are engraved in the literature corpus and reported on as artifacts in papers [27, 33].

[1] [16] refers to [31 p. 10].

3.1 Taxonomy Development

To develop the taxonomy, we use the 7-step method of Nickerson et al. [26]. **Step (1)** defines a meta-characteristic, which is the superordinate goal the taxonomy is supposed to fulfill. In our case, the meta-characteristic reads as follows:

Meta-Characteristic: '*Provide Design Options for Visual Inquiry Tools based on Conceptual and Empirical Design Dimensions and Design Characteristics.'*

Next, **step (2)** prescribes settling on ending conditions, which we draw from Nickerson et al. [26]. They propose five subjective and eight objective ending conditions that we adopt. **Step (3)** is the dichotomous decision between a *conceptual-to-empirical* (deductive) **(Steps 4c-6c)** or *empirical-to-conceptual* (inductive) **(Steps 4e-6e)** approach. In our case, we first screen the literature on conceptual papers on VITs to incorporate design elements into the taxonomy. After that, we add two *empirical-to-conceptual* iterations. The first one generates design options inductively from VITs that we collect through a *systematic literature review*. In the second empirical-to-conceptual iteration, we analyze a sample of 15 VITs from the application-oriented view (i.e., outside of academic publishing) that we collect through an internet search. Yet, our investigation revealed that VITs outside of academia usually do not have a precise design method explaining why and how they were designed. Thus, we could not compare the application-driven VIT's design method to those of research-driven VITs, which clearly outlined the applied research method (e.g., DSR). We adopt the objective and subjective ending conditions for taxonomy design as proposed by the method explained above **(Step 7)**. After three iterations, we fulfilled the ending conditions, ending the iterative *design cycles*. For instance, after the final iteration, we were able to classify all of the samples and produced a taxonomy consisting of 10 dimensions, which is just shy above the average number of dimensions per taxonomy [34]. Given that we could classify all objects, we can also draw conclusions about their applicability (see Table 4).

3.2 Systematic Literature Review and Desk Research

Our data collection process follows a *systematic literature review* approach based on Webster & Watson [27]. Given our goal of designing a taxonomy with design options, we collect the data in a concept matrix. Additionally, we do not strive to collect all VITs, as a representative sample is sufficient to reach theoretical saturation in how they can be designed and aligned with taxonomy design [26, 33, 35]. We drew our sample from the *AISeL* database, including relevant conferences and journal outlets that are likely to contain VITs. For example, the database includes papers from *HICSS*, which often had a dedicated track for *visual collaboration tools* in the past [36, 37]. Subsequently, our sample includes papers from conference proceedings of *ECIS, HICSS, WI, Pre-ICIS Workshops, BLED, MCIS,* and *DESRIST*. Additionally, we collected conceptual papers explicating VIT design or the theoretical underpinnings (e.g., see [1, 4, 8]). Subsequently, we searched using the keywords 'visual inquiry tool' [8], 'visual innovation tool', and 'design canvas' [7] (see Table 2).

We complement the findings from the literature corpus with empirical examples collected in a Google search, searching for 'design canvas' or 'visual inquiry tools'. We collected a sample of 15 VITs through that search that we use in the empirical-to-conceptual iteration.

Table 2. Findings from the literature review (initial findings n = 41) and Google search (for empirical examples) including forward and backward search.

Literature Review		Google Search
Outlet	**Relevant**	**Relevant**
ECIS	5	15
Pre-ICIS WS	2	
HICSS	6	
WI	3	
BLED	1	
DESRIST	4	
MCIS	1	
EM	1	
Other	1	
∑	**24**	**15**

Table 3 shows a high-level categorization of our sample according to whether the VIT is new or an adaption. The sample includes a diverse set of VITs with different *foci*. The largest segment of VITs thematizes innovation based on *data*. Given the importance of data for business model innovation [38, 39] and, in general, digital transformation, generating VITs on that is not surprising. For example, these include VITs for *data products* [6], *data-driven business models* [12], or *data-based (analytics) services* [16]. The second-largest segment develops VITs to represent research processes. For example, that includes a VIT on *literature reviews* [13], the

DSR-grid [10], or a *portrait of design essence* [3]. The focus of other VITs is idiosyncratic, as they are unique in their category. For example, that includes VITs for *requirements engineering* [40], *AI public value* [41], or *general ideation* [42].

Table 3. Overview of the literature sample used to develop design options.

Category	New	Adapted
Data Innovation	[6, 15, 16, 43–45]	[12]
Service Design	[21]	[14, 46, 47]
Methods & Processes	[7, 10, 11, 13, 48]	[3]
Organization	[2, 49]	-
Req. Engineering	[40]	-
Gamification	-	[50]
Ideation	[42]	-
Digital Transformation	-	[51]
P2P-Sharing & Consumption	-	[52]
AI-Public Value	-	[41]

4. Visual Inquiry Tool Design Options

In the following, we illustrate the final taxonomy and detail all *design options* derived from our research. The final taxonomy consists of 10 dimensions and corresponding characteristics. Table 4 shows the final taxonomy and indicates the origin of each dimension as well as their exclusivity. For example, designers must choose between either following an *Action Design Research (ADR)* or a *Design Science Research (DSR)* approach *exclusively*. Other design options, e.g., whether the VIT is based on a digital template, printed version, or software tool, are not *mutually exclusive*.

To give additional structure to the taxonomy and the design options, we use the concept *meta-dimensions*, which are high-level elements organizing dimensions and characteristics (e.g., see [38] or [53]). We draw from design fundamentals since we focus on steps required to design VITs and, correspondingly, see it as a model in terms of artifacts [17]. Design is both a verb and a noun, describing the design process and design product (we use the term *design solution* to mirror the initial *design problem*) [54]. It also is the iterative progression from a problem with a set of requirements that trigger an intervention to an evaluated artifact [55]. Subsequently, we see four meta-dimensions that we use as a lens to analyze the VITs [56], i.e., the *design problem, design process, design solution, and design evaluation.*

4.1 Meta-Dimension 1: Design Problem

The first meta-dimension – *Design Problem* **(MD_1)** – includes two dimensions that conceptualize the initial purpose and reason for designing a VIT.

The first dimension – *Design Purpose (D_{11})* – describes the initial offsetting reason to design the VIT. Notably, we want to distinguish that trigger from typical advantages of VITs, such as *visualization* or *interdisciplinarity*. We see four high-level reasons. The first dimension refers to *Collaborative Ideation (C_{111}). It* describes VITs that are supposed to act as a space for shared ideation. For example, Lecuna et al. [42] explicitly propose the *Idea Arc*, a VIT for developing new ideas in 14 'building blocks', including, for instance, 'Idea name and description' or 'Alternative ideas'. The second characteristic explicitly refers to *Designing New Artifacts (C_{112})*. A typical example is the *Service Business Model Canvas (SBMC)*, which adapts the existing business model canvas and is used to design new service-based business models [14, 47]. Last, the characteristic *Analyze/Support Process (C_{113})* thematizes using VITs to represent or structure research processes. For example, Schoormann et al. [13] propose a VIT to structure literature reviews in 9 'building blocks' based on established methodological literature review papers. Fourth, the purpose of a VIT can be *Alignment (C_{114})*, e.g., in the *Team Alignment Map*[2] or *Culture Canvas*[3].

The second dimension – *Design Element (D_{12})* – describes the underlying phenomenon that the VIT addresses. For example, a variety of VITs are explicitly tailored to developing new artifacts based on *Data (C_{121})* (e.g., see [6]). Other design elements are *Gamification* (C_{122}), *Digital Transformation (C_{123})*, *Requirements Engineering (C_{124})*, *Organizational Phenomena* (e.g., workspaces [49] or brand identity [2]) *(C_{125})*, *Ideas (C_{126})*, *Research Processes (C_{127})*, *Services* (as an extension of business models [14, 47]) *(C_{128})*, *Public Value (C_{129})*, *Business Models (C_{1210})*, *Mobile Applications (C_{1211})*, *Artificial Intelligence (C_{1212})*, or *Digital Platforms (C_{1213})*. The characteristics of the dimension are not mutually exclusive as they can be combined to generate new VITs. Kühne & Böhmann [12] combine the design elements *data* and *business model* and propose a VIT to designing data-driven business models.

[2] See https://www.teamalignment.co/ last accessed: 28-05-2021

[3] See https://culturecanvas.biz/#the-culture-canvas last accessed: 28-05-2021

Table 4. Design Options for Visual Inquiry Tools. MD = Meta Dimension, EX = Exclusivity

MD	Dimension	Characteristics					EX
Design Problem	Design Purpose	Collaborative Ideation	Design a New Artifact	Analyze / Support Process	Alignment		No
	Design Element	Data	Gamification	Digital Transformation	Requirements Engineering		No
		Organizational Phenomenon	Ideas	Research Process	Services	Public Value	
		Business Models	Mobile Applications	Artificial Intelligence	Digital Platforms	…	
Design Process	Design Method	ADR	DSR				Yes
	Design Philosophy	Ontology-Based	Requirements/ Principle-Based				Yes
	Design Requirement Source	Interviews	Survey	Workshops	Literature		No
Design Solution	Design Origin	New	Adapted				Yes
	Design Medium	Print-Out	Digital Template	Application			No
	Design Output	Stand-Alone	Part of a Toolkit				Yes
Design Evaluation	Evaluation Strategy	Case Study	Workshops	A/B-Test	Focus Group	Questionnaire	No
	Evaluation Criteria	Usability	Practicability	Impact	Usefulness		No
		Efficacy	Effectiveness	Efficiency	Elegance	Ethicality	

The dimension is by no means *exhaustive*, as it only describes the existing design elements of our sample. Naturally, it can and should be extended through other design elements. Also, we decided not to include all design elements from the empirical iteration (e.g., applications or culture) since the sheer number would damage conciseness at the benefit of merely listing additional design elements.

4.1 Meta-Dimension 2: Design Process

The second meta-dimension – *Design Process* – **(MD_2)** conceptualizes dimensions and characteristics, referring to the processual steps of designing the VIT. The process is triggered by conceptualizing the *Design Problem*, i.e., a problem-to-be-solved to design the VIT, and concludes with requirements for the *Design Solution*.

The dimension *Design Method* *(D_{21})* refers to the research paradigm one follows to develop the VIT. Based on our findings, we can differentiate between two dominant approaches. First, *Design Science Research* (DSR) that authors operationalize most frequently through the method of Peffers et al. [22] (e.g., see [21] or [15]) *(C_{211})*. Second, authors develop VITs in *Action Design Research* (ADR) [57] studies *(C_{212})*. Table 5 shows the design methods and their distribution across the literature sample.

The second dimension – *Design Philosophy* *(D_{22})* – indicates the conceptual basis authors use to justify the 'building blocks' of the VIT. Following current design principles, VITs should rely on an underlying *Ontology* [8] *(C_{221})*. Authors derive these ontologies from multiple sources, such as *interviews* (e.g., [42]) or *literature* ([21]). Contrarily, authors use *a priori* generated *requirements* or *design principles* (e.g., see [15]). For example, Fruhwirth et al. [6] develop their VIT for data products by observing a problem in a DSR study and eliciting corresponding design requirements from the literature and a *case study*. Hunke et al. [15] develop a VIT based on *meta-requirements* grounded in the literature and an interview study and corresponding design principles *(C_{222})*.

Table 5. Overview of Design Methods.

Design Method	N	#
Action Design Research (ADR)	**5**	**21%**
Sein et al. (2011) [57]	5	100%
Design Science Research (DSR)	**16**	**67%**
Peffers et al. (2007) [22]	10	63%
Hevner et al. (2004) [58]	1	6%
Kuechler & Vaishaniva (2008) [59]	2	13%
Synthesized / Undefined	3	19%
Undefined/Unclear	**3**	**13%**

The third dimension – *Design Requirements* *(D_{23})* – describes problems-to-be-solved as requirements that shape why and how the VIT comes into existence. For example, these range from identifying gaps in the literature and deriving requirements from that or eliciting requirements from practice-oriented workshops. Subsequently, we propose four characteristics based on our findings. First, collecting design requirements in *Interviews* *(C_{231})*, such as Elikan & Pigneur [2], who collect interviews on brand identity to identify common problems. Another variant is collecting requirements and problems through *Surveys (C_{232})* [43]. Third, Rose et al. [46] use *Workshops* with practitioners to develop solution objectives for the VIT *(C_{233})*. Fourth, VITs can be based on findings in the *Literature (C_{234})* [12]. The dimension is not mutually exclusive as these knowledge bases can be combined for triangulation.

4.3 Meta-Dimension 3: Design Solution

The third meta dimension – *Design Solution* – **(MD_3)** produces dimensions and characteristics referring to the design solution.

The dimension *Design Origin (D_{31})* refers to one of two ways the VIT can be developed. First, a new VIT tackling a previously untapped field without drawing from existing solutions *(C_{311})*. Alternatively, authors choose to *adapt* existing VITs (a widespread basis being the *business model canvas* [28]) *(C_{312})* (see Table 6).

Table 6. Exemplary design foundations.

Visual Inquiry Tool	Design Foundation
Idea Arc [42]	**New** VIT to design ideas
Modularity Canvas [21]	**New** VIT to design modular service architecture
Data Canvas [45]	**New** VIT to consider data resources
BMC for P2P Sharing and Collaborative Consumption [52]	**Adapted** from BMC
Service Business Model Canvas [14]	**Adapted** from BMC
Service Innovation for the Public Sector [46]	**Adapted** from BMC

The dimension *Design Medium (D_{32})* describes how the VIT is used. We found three ways that are *not mutually exclusive*. First, traditionally, the VIT is supposed to be *printed out* and used in physical workshop settings *(C_{321})*. For example, Poeppelbuß & Lubarski [21] provide photos of in-person sections with filled-out modularity canvases. Second, VITs are provided to be used via *digital templates* (e.g., see Kühne & Böhmann [12] or the *Platformdesigntoolkit*[4] in *Miro*[5]) *(C_{322})*. Through the empirical examples, we add the characteristic *application (C_{323})*, describing VITs embedded in a software application (e.g., see *Strategyzer*[6]).

The third dimension – *Design Output (D_{33})* – differentiates between the VIT being a *Stand-alone Tool (C_{331})* or *Part of a Toolkit (C_{332})*. In our sample, VITs are usually stand-alone canvases not integrated into a series of VITs. Yet, Avdiji et al. [8] already highlight the benefit of developing more detailed VITs for 'building blocks' that are potentially too generic.

4.4 Meta-Dimension 4: Design Evaluation

The fourth meta-dimension – *Design Evaluation* – **(MD_4)** provides an overview of the evaluation strategies and criteria to validate and or iterate the VIT.

The dimension *Evaluation Strategy (D_{41})* explains the technique of evaluating the VIT. These differ fivefold, in *Case Studies (C_{411})*, *Workshops (C_{412})*, *A/B Tests (C_{413})*, *Focus Group Interviews (C_{414})*, or *Questionnaires (C_{415})*. For example, Elikan & Pigneur [2] evaluate their VIT for brand identity with start-ups, while Kronsbein & Müller [43] evaluate their canvas for data thinking in a workshop setting. Hunke et al. [15] collect feedback on their canvas in a focus group interview following the guidelines of Tremblay et al. [60]. Lastly, Schoormann et al. [13] evaluate their VIT for literature reviews in an A/B-test in two groups.

In terms of *Evaluation Criteria (D_{42})*, authors usually point to one or multiple of nine characteristics, namely *Usability (C_{421})*, *Practicability (C_{422})*, *Impact (C_{423})*, and *Usefulness (C_{424})*. Avdiji et al. [8] point to *Efficacy (C_{425})*, *Effectiveness (C_{426})*, *Efficiency (C_{427})*, *Elegance (C_{428})*, and *Ethicality (C_{429})*.

5. Analysis

In this section, we analyze our findings twofold. First, we align our results with existing design guidance for VITs (see Section 5.1) and, second, derive implications for further research.

5.1 Alignment with Existing Design Guidance

Our work produces *design options* for VITs. It strictly focuses on a processual view that addresses the design process and considers necessary design steps

[4] https://platformdesigntoolkit.com/ last-accessed 23-05-2021

[5] See https://go.miro.com/platform-design-toolkit last-accessed 23-05-2021

[6] See https://www.strategyzer.com/app last-accessed 23-05-2021

covering the *design problem*, *design process*, *design solution*, and *design evaluation*.

We identify two existing types of design guidance. First, the design theory for VITs and its design principles of Avdiji et al. [1, 8], and the morphological characteristics engraved in the design space for innovation canvases of Thoring et al. [4].

First, the design theory for VITs includes a set of design principles prescribing various central elements for their design based on the codification of priorly gained design knowledge. These design principles prescribe, for example, the generation of a *conceptual model* (usually an ontology) that explains, justifies, and rationalizes the 'building blocks' and their later arrangement. In this case, our design options extend the design principles since our literature analysis also revealed a justificatory design path for VITs via *meta-requirements*, *design requirements* and/or *design principles* (e.g., see [6, 15, 16, 46]).

Other design principles prescribe that the conceptual model should foster shared visualization through generating empty spaces that can be enriched with directions for use that should assist designers in using the VIT. Our design options complement the design principles by giving additional design dimensions. For example, while the design theory prescribes that the VIT should be on an adequately general level and that particular issues can be broken down into additional VITs, it is not a design option *per se*. Our work complements this by including design options analyzing whether the VIT should stand for itself or be part of a process (e.g., a comprehensive method). We argue that this decision is highly important, as developing VITs as part of a process requires defining inputs and outputs that enable them to be used in a value chain.

Next, our work also complements the design space for innovation canvases as proposed by Thoring et al. [4]. The design space is codified as a morphological box with six *design parameters*, including *process step*, *media*, *sequence*, *instructions*, *elements*, and *design specifics*. The morphological box offers parameters that describe morphological characteristics of VITs, e.g., the number of building blocks that they have (elements), whether and how they come with instructions for use (instructions), or how they are supposed to be used (e.g., post-its, stickers, or with computer support). Given these parameters, our design options presented here complement them by explicating design process characteristics, such as the underlying design method or evaluation techniques.

5.2 Implications of our Findings

We derive a set of propositions for further research on designing VITs from our analysis. In particular, we derive these learnings from the comparison of literature-based findings and empirical examples. For instance, papers usually report on single instances of VITs and drastically narrow the focus of analysis. In our empirical examples, we found examples of complete sets of VITs that decompose a phenomenon of interest in multiple instances of VITs (e.g., the *PlatformDesignToolKit*[7]). Subsequently, we formulate the following propositions:

- **Research should address VIT kits**: Given that VITs are usually developed to solve complex problems without a straightforward solution, it is surprising that most papers focus on a single solution rather than on a toolkit. Avdiji et al. state that "If subcomponents are deemed important, they can be used to develop additional tools" [8 p. 22]. From that, we can infer a need to identify whether more than one VIT would be necessary to understand a phenomenon fully and, if so, whether they have a hierarchical order and interdependencies. A prominent example of additional tools is the *Value Proposition Canvas*, which zooms in on two 'building blocks' of the *Business Model Canvas* [28], namely, the *value proposition* and the *customer segment*.
- **Research should address tool-support:** From our sample, it is clear that VITs are mainly developed to be printed out and used in live workshop settings. Subsequently, the dominant medium they are delivered in is analog or digital templates. Yet, there are examples of canvases enhanced by tools that have specific tool support (which is also a parameter of Thoring et al. [4]), such as the *Strategyzer*[8] or the tool-supported adaption of the BMC for sustainability by Schoormann et al. [61]. Given the potential advantages of tool-support, e.g., *shared visualization* or *interdisciplinary collaboration* [2, 51, 62], we see the increasing investigation of tool-supported VITs as a highly relevant avenue for further research. Primarily, we see benefits for the greater field of designing solutions through tool-support, which is an ongoing discussion in the field of design science research [63].

6. Contributions, Limitations, Outlook

Our work provides multiple contributions. First, in terms of **research contributions**, we complement existing research on design guidance for VITs. Thus

[7] https://platformdesigntoolkit.com/ 23-05-2021

[8] https://www.strategyzer.com/app 20-05-2021

we make the spectrum of design options transparent and entangle them with existing prescriptions [8]. Subsequently, our work contributes to the rigor of VIT design and, ultimately, should enhance the quality of the artifact and the purpose that it should fulfill. Given that we provide an overview of VITs (knowing the limitation that we did not find all existing VITs in the literature), our contribution to knowledge accumulation paints a picture of a sample of VITs and what they consider in their design (see Table 3). Researchers can use our taxonomy to design new VITs altogether or as a template to analyze existing VITs. Also, we derive propositions for research areas that merit detailed analysis and complement existing design guidance (see Section 5.1 and Section 5.2).

In terms of the **practical contribution,** our work has direct and indirect effects. First, similar to our research contributions, practitioners can use our design options to develop VITs for more practice-inspired application scenarios that require collaborative tools for problem-solving. Second, we hope to spur new VITs for additional domains, technologies, applications, or other potential phenomena of interest by giving researchers and practitioners design options. Practitioners (e.g., project managers) can draw from our collection of VITs to find suitable tools for their needs more swiftly.

Naturally, our work is subject to **limitations**. Our findings result from a literature review that we limited to one database and *forward & backward search*. Subsequently, our findings mainly consider VITs developed in the Information Systems field, which is a potential explanation for the heavy focus on DSR and ADR (see Table 5). As the taxonomy builds on our sample, new dimensions and characteristics may arise when extending the sample. For example, new VITs have been proposed exceeding the time frame of our research (e.g., see [64]). In future work, that sample needs to be extended to more databases and include, perhaps, additional VITs or VIT categories that our sample (see Table 3) does not cover. Also, the development of the design options through taxonomic analysis requires some degree of qualitative assessment. Additionally, not all dimensions could be filled out for all papers. Subsequently, other researchers might identify additional design options or might consider others to be more critical.

Our research provides multiple **avenues for further research**. First and foremost, researchers can use our design options as a basis to extend them, refine them, or specify them. The next steps should also include collecting feedback from practitioners on designing effective and efficient VITs. We propose general and generic design options, which can be tailored for specific VITs. Mainly that is valuable as its users might identify new design options specific to a particular field of VIT (e.g., those focusing on research processes against business model innovation). For example, business model design is a vast landscape meriting detailed design options explicitly for VITs developing business models. Lastly, enriching the taxonomy through more data sources (e.g., qualitative interview studies) could reveal new dimensions and characteristics.

References

[1] Avdiji, H., D.A. Elikan, S. Missonier, and Y. Pigneur, "Designing Tools for Collectively Solving Ill-Structured Problems", in Proceedings of the 51st Hawaii International Conference on System Sciences, Hawaii: USA. 2018.

[2] Elikan, D.A. and Y. Pigneur, "A visual inquiry tool for brand identity", in Proceedings of the 52nd Hawaii International Conference on System Sciences, Hawaii: USA. 2019.

[3] Chandra Kruse, L. and J. Nickerson, "Portraying Design Essence", Proceedings of the 51st Hawaii International Conference on System Sciences, 2018, pp. 4433–4442.

[4] Thoring, K., R. Mueller, and P. Badke-Schaub, "Exploring the Design Space of Innovation Canvases", in Academy for Design Innovation Management Conference (ADIM), London: UK. 2019.

[5] Simon, H.A., "The structure of ill structured problems", Artificial Intelligence, 4(3-4), 1973, pp. 181–201.

[6] Fruhwirth, M., G. Breitfuss, and V. Pammer, "The Data Product Canvas: A Visual Collaborative Tool for Designing Data-Driven Business Models", in In Proceedings of the 33rd BLED eConference, BLED: Slovenia. 2020.

[7] Morana, S., M. Scheid, M. Gau, I. Benke, J. Vom Brocke, P. Fettke, and A. Maedche, "Research prototype: The design canvas in MyDesignProcess. com", in Proceedings of the 13th International Conference on Design Science Research in Information Systems and Technology, Chennari: India. 2018.

[8] Avdiji, H., D.A. Elikan, S. Missonier, and Y. Pigneur, "A Design Theory for Visual Inquiry Tools", Journal of the Association for Information Systems, 21(2), 2020, pp. 695–734.

[9] Dalsgaard, P., "“Instruments of Inquiry: Understanding the Nature and Role of Design Tools", International Journal of Design, 11(1), 2017, pp. 21–33.

[10] Vom Brocke, J. and A. Maedche, "The DSR grid: six core dimensions for effectively planning and communicating design science research projects", Electronic Markets, 29(3), 2019, pp. 379–385.

[11] Nagle, T., D. Sammon, and C. Doyle, "Insights into Practitioner Design Science Research", in Designing the Digital Transformation, A. Maedche, J. Vom Brocke, and A. Hevner, Editors. 2017. Springer International Publishing: Cham.

[12] Kühne, B. and T. Böhmann, "Data-Driven Business Models - Building the Bridge Between Data and Value", in Proceedings of the 27th European

Conference on Information Systems, Uppsala and Stockholm: Sweden. 2019.

[13] Schoormann, T., D. Behrens, M. Fellmann, and R. Knackstedt, "On Your Mark, Ready, Search: A Framework for Structuring Literature Search Strategies in Information Systems", in Proceedings of the 16th International Conference on Wirtschaftsinformatik, Essen: Germany (Digital). 2021.

[14] Zolnowski, A., C. Weiß, and T. Böhmann, "Representing Service Business Models with the Service Business Model Canvas - The Case of a Mobile Payment Service in the Retail Industry", in Proceedings of the 47th Hawaii International Conference on System Science, Hawaii: USA. 2014.

[15] Hunke, F., S. Seebacher, and H. Thomsen, "Please Tell Me What to Do - Towards a Guided Orchestration of Key Activities in Data-Rich Service Systems", in Designing for Digital Transformation. Co-Creating Services with Citizens and Industry, S. Hofmann, O. Müller, and M. Rossi, Editors. 2020. Springer International Publishing: Cham.

[16] Hunke, F. and F. Kiefer, "Designing Analytics-Based Services - Exploring Design Requirements for Methodological Tool Assistance in Service Design Teams", in Proceedings of the 15th International Conference on Wirtschaftsinformatik, Potsdam: Germany. 2020.

[17] Glass, R.L. and I. Vessey, "Contemporary Application-Domain Taxonomies", IEEE Software, 12(4), 1995, pp. 63–76.

[18] van der Valk, H., H. Haße, F. Möller, M. Arbter, J.-L. Henning, and B. Otto, "A Taxonomy of Digital Twins", in Proceedings of the 2020 Americas Conference on Information Systems, Salt Lake City: USA. 2020.

[19] Azkan, C., L. Iggena, I. Gür, F. Möller, and B. Otto, "A Taxonomy for Data-Driven Services in Manufacturing Industries", in Proceedings of the 24th Pacific Asia Conference on Information Systems, Dubai: UAE. 2020.

[20] March, S.T. and G.F. Smith, "Design and Natural Science Research on Information Technology", Decision Support Systems, 15(4), 1995, pp. 251–266.

[21] Poeppelbuss, J. and A. Lubarski, "Modularity Canvas - A Framework for Visualizing Potentials of Service Modularity", in Proceedings of the 14th International Conference on Wirtschaftsinformatik, Siegen: Germany. 2019.

[22] Peffers, K., T. Tuunanen, M.A. Rothenberger, and S. Chatterjee, "A Design Science Research Methodology for Information Systems Research", Journal of Management Information Systems, 24(3), 2007, pp. 45–77.

[23] Baker, L.R., "The shrinking difference between artifacts and natural objects", American Philosophical Association Newsletter on Philosophy and Computers, 7(2), 2008.

[24] Simon, H.A., "Problem Forming, Problem Finding and Problem Solving in Design", Design & systems, 1995, pp. 245–257.

[25] Möller, F., H. Haße, C. Azkan, H. van der Valk, and B. Otto, "Design of Goal-Oriented Artifacts from Morphological Taxonomies: Progression from Descriptive to Prescriptive Design Knowledge", in Proceedings of the 16th International Conference on Wirtschaftsinformatik, Essen: Germany (Digital). 2021.

[26] Nickerson, R.C., U. Varshney, and J. Muntermann, "A Method for Taxonomy Development and its Application in Information Systems", European Journal of Information Systems, 22(3), 2013, pp. 336–359.

[27] Webster, J. and R.T. Watson, "Analyzing the Past to Prepare for the Future: Writing a Literature Review", MIS Quarterly: Management Information Systems, 26(2), 2002, pp. xiii–xxiii.

[28] Osterwalder, A. and Y. Pigneur, Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Wiley, 2013.

[29] Osterwalder, A., The Business Model Ontology: A Proposition in a Design Science Approach, 2004.

[30] Avdiji, H., Supporting the Challenges of Cross-Boundary Teamwork through Design Science Research, 2018.

[31] Sanders, E.B.-N., "Generative Tools for Co-designing", in Collaborative Design, S.A.R. Scrivener, L.J. Ball, and A. Woodcock, Editors. 2000. Springer London: London.

[32] Szopinski, D., T. Schoormann, and D. Kundisch, "Because your taxonomy is worth it: Towards a framework for taxonomy evaluation", in Proceedings of the Twenty-Seventh European Conference on Information Systems, Uppsala, Sweden. 2019.

[33] Cooper, H.M., "Organizing Knowledge Syntheses: A Taxonomy of Literature Reviews", Knowledge in Society, 1(1), 1988, pp. 104–126.

[34] Oberländer, A.M., B. Lösser, and D. Rau, "Taxonomy research in information systems: A systematic assessment", in Proceedings of the 27th European Conference on Information Systems, Uppsala and Stockholm: Sweden. 2019.

[35] Randolph, J.J., "A Guide to Writing the Dissertation Literature Review", Practical Assessment, Research & Evaluation, 14(13), 2009, pp. 1–13.

[36] Missonier, S., K. Lyytinen, and Y. Pigneur, "Introduction to the Minitrack on Developing Visual Collaborative Tools", in Proceedings of the 52nd Hawaii International Conference on System Sciences, Hawaii: USA. 2019.

[37] Missonier, S., H. Avdiji, Y. Pigneur, and R. Winter, "Introduction to the Minitrack on Developing Visual Collaborative Tools", in Proceedings of the 53rd Hawai Conference on System Sciences. 2020: Hawaii: USA.

[38] Möller, F., M. Stachon, C. Hoffmann, H. Bauhaus, and B. Otto, "Data-Driven Business Models in Logistics: A Taxonomy of Optimization and Visibility Services", in Proceedings of the 53rd Hawaii International Conference on System Sciences, Hawaii: USA. 2020.

[39] Hartmann, P.M., M. Zaki, N. Feldmann, and A. Neely, "Capturing Value from Big Data – A Taxonomy of Data-Driven Business Models Used by Start-Up Firms", International Journal of Operations & Production Management, 36(10), 2016, pp. 1382–1406.

[40] Ruf, C. and A. Back, "How Can We Design Products, Services, and Software That Reflect the Needs of Our

Stakeholders? Towards a Canvas for Successful Requirements Engineering", in New Horizons in Design Science: Broadening the Research Agenda, B. Donnellan, M. Helfert, J. Kenneally, D. VanderMeer, M. Rothenberger, and R. Winter, Editors. 2015. Springer International Publishing: Cham.

[41] Samar, F., K. Desouza, C. Buck, and E. Fielt, "Business Model Canvas to Create and Capture AI-enabled Public Value", in Proceedings of the 54th Hawaii International Conference on System Sciences, Hawaii: USA. 2021.

[42] Lecuna, A., K. Thoring, and R. Mueller, "The Idea Arc: Designing a Visual Canvas for Fuzzy Ideas", in Proceedings of the 52nd Hawaii International Conference on System Sciences, Hawaii: USA. 2019.

[43] Kronsbein, T. and R. Müller, "Data Thinking: A Canvas for Data-Driven Ideation Workshops", in Proceedings of the 52nd Hawaii International Conference on System Sciences, Hawaii: USA. 2019.

[44] Kayser, L., R. Mueller, and T. Kronsbein, "Data Collection Map: A Canvas for Shared Data Awareness in Data-Driven Innovation Projects", in Pre-ICIS SIGDSA Symposoium on Inspiring mindset for Innovation with Business Analytics and Data Science, Munich: Germany. 2019.

[45] Mathis, K. and F. Köbler, "Data-Need Fit–Towards data-driven business model innovation", in Service Design Geographies. Proceedings of the ServDes. 2016 Conference. 2016.

[46] Rose, J., J. Holgersson, and E. Söderström, "DESIGNING INNOVATIVE DIGITAL SERVICES FOR GOVERNMENT: A BUSINESS MODEL CANVAS ADAPTATION", in Proceedings of the 27th European Conference on Information Systems, Uppsala and Stockholm: Sweden. 2019.

[47] Zolnowski, A. and T. Böhmann, "Formative evaluation of business model representations - The service business model canvas", in Proceedings of the 22nd European Conference on Information Systems, Tel Aviv: Israel. 2014.

[48] Nagle, T. and D. Sammon, "The development of a practitioner design science research canvas", in AIS SIGPRAG: pre-ICIS Workshop 2016: Practice-based Design and Innovation of Digital Artifacts, Dublin: Ireland. 2016.

[49] Thoring, K., R. Mueller, and P. Badke-Schaub, "Assessing and Changing an Organization's Innovation Culture with the Workspace Catalyst Canvas". 2020.

[50] Korhonen, T., R. Halonen, T. Ravelin, J. Kemppainen, and K. Koskela, "A MULTIDISCIPLINARY APPROACH TO SERIOUS GAME DEVELOPMENT IN THE HEALTH SECTOR", in Proceedings of the 11th Mediterranean Conference on Information Systems, Genoa: Italy. 2017.

[51] Reijnen, C., S. Overbeek, G. Wijers, and A. Sprokholt, "A Shared Vision for Digital Transformation: Codification of The Operating Model Canvas Approach", in Proceedings of the 26th European Conference on Information Systems, Portsmouth: United Kingdom. 2018.

[52] Plenter, F., E. Fielt, M. von Hoffen, F. Chasin, and M. Rosemann, "Repainting the Business Model Canvas for Peer-to-Peer Sharing and Collaborative Consumption", in Proceedings of the 25th European Conference on Information Systems, Guimarães: Portugal. 2017.

[53] Remane, G., R.C. Nickerson, A. Hanelt, J.F. Tesch, and L.M. Kolbe, "A Taxonomy of Carsharing Business Models", in Proceedings of the 37th International Conference on Information Systems, Dublin: Ireland. 2016.

[54] Walls, J.G., J. G, Widmeyer, G. R, O. Sawy, and O. A, "Building an Information System Design Theory for Vigilant EIS", Information Systems Research, 3(1), 1992, 36-59.

[55] Purao, S., A. Bush, and M. Rossi, "Problem and Design Spaces During Object-oriented Design: An Exploratory Study", in Proceedings of the 34th Annual Hawaii International Conference on System Sciences, Hawaii: USA. 2001.

[56] Niederman, F. and S. March, "The "Theoretical Lens" Concept: We All Know What it Means, but do We All Know the Same Thing?", Commun. Assoc. Inf. Syst., 44(1), 2019, pp. 1–33.

[57] Sein, M.K., O. Henfridsson, S. Purao, M. Rossi, and R. Lindgren, "Action Design Research", MIS Quarterly: Management Information Systems, 35(1), 2011, pp. 37–56.

[58] Hevner, A.R., S.T. March, J. Park, and S. Ram, "Design Science in Information Systems Research", MIS Quarterly: Management Information Systems, 28(1), 2004, pp. 75–105.

[59] Kuechler, B. and V. Vaishnavi, "On theory development in design science research: anatomy of a research project", European Journal of Information Systems, 17(5), 2008, pp. 489–504.

[60] Tremblay, M., A. Hevner, and D. Berndt, "Focus Groups for Artifact Refinement and Evaluation in Design Research", Communications of the Association for Information Systems, 26(27), 2010, pp. 599–618.

[61] Schoormann, T., M. Stadtländer, and R. Knackstedt, "Designing business model development tools for sustainability—a design science study", Electronic Markets, 2021.

[62] Steffen, B. and S. Boßelmann, "GOLD: Global Organization aLignment and Decision - Towards the Hierarchical Integration of Heterogeneous Business Models", in Leveraging Applications of Formal Methods, Verification and Validation. Industrial Practice, T. Margaria and B. Steffen, Editors, Cham, 2018. 2018. Springer International Publishing: Cham.

[63] Morana, S., J. Vom Brocke, A. Maedche, S. Seidel, M. Adam, U. Bub, P. Fettke, M. Gau, A. Herwix, M. Mullarkey, H. Nguyen, J. Sjöström, P. Toreini, L. Wessel, and R. Winter, "Tool Support for Design Science Research-Towards a Software Ecosystem: A Report from a DESRIST 2017 Workshop", Communications of the Association for Information Systems, 43(17), 2018, pp. 237–256.

[64] Möller, F., T. Schoormann, and B. Otto, "'Caution - Principle Under Construction' - A Visual Inquiry Tool for Developing Design Principles", in DESRIST 2021, Chandra Kruse, L., Seidel, S., Editor, Kristiansand: Norway. 2021.