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Guiding Design Principle Projects: A Canvas for Young Design Science Researchers

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ABSTRACT

Particularly young researchers face challenges in organizing large design science research (DSR) projects and often struggle to capture, communicate, and reflect on important components to produce purposeful outcomes. Making informed decisions at the project start, such as selecting suitable kernel theories and development procedures, is of great relevance because they affect the entire design process and the resulting design products. Although DSR can produce different types of outcomes, from more situational artifacts to more abstract design knowledge, scholars point to the need for generalizing insights collected in such projects to advance the knowledge base. As design principles are among the prevailing forms of such design knowledge, this paper builds a visual inquiry tool—represented as a canvas—that navigates researchers through common components for crafting design principles and leverages collaborative reflections on essential project decisions. To build our canvas, we adapt inquiry-based learning (IBL) guidelines and visual inquiry tools to DSR education. Evaluations with doctoral students revealed promising indications for the canvas's applicability and usefulness in guiding iterative DSR projects, reflecting on basic components, and communicating work-in-progress to other scholars and practice. Overall, we complement the body of DSR literature by providing an educational visual inquiry tool for producing design principles.

Keywords: Curriculum design & development, Education, Visualization, Visual inquiry tool, Design science

1. INTRODUCTION

The primary goal of Design Science Research (DSR) is to produce and accumulate design knowledge on the solution to real-world problems (vom Brocke et al., 2020). Given its potential to solve such problems, DSR has increasingly received interest in tackling economic but also social and environmental challenges (Seidel et al., 2018). A potential that should be released already in the early stages of professional careers to empower people to create sustainable innovations.

In addition to the DSR's mission to build artifacts, there is also a need for abstracting the results and insights from single instances to advance the general knowledge base (Baskerville et al., 2018; Lee & Baskerville, 2003). This presumes abilities to reflect on experiences collected from the design of an artifact, which should be part of information systems (IS) education (Goldkuhl et al., 2017). To fulfill the need for abstraction, researchers can draw on various approaches to formalizing design-relevant knowledge, such as technological rules and design rules. Among the most dominant ones in IS research is design principles, which are indicated by Möller et al.'s (2022) frequency analysis of such formalization mechanisms. Design principles capture prescriptive statements to guide artifact designers and are recognized as an important outcome of design projects (Gregor et al., 2020; Sein et al., 2011).

To produce design principles, young researchers, such as Ph.D.- and Master's students, often navigate through the broad landscape of DSR literature to distill methodological guidance. As there is a rich body of DSR methods, several choices must be made (Smuts et al., 2022). Typically, these choices appear in the early stages of a project, including reflections on the actual class of problems and decisions about the underlying paradigm. To obtain feedback and discuss the consequences of their choices, young researchers need to communicate their projects to advisors, peers, and reviewers (Cahenzli, 2022). From our talks with (young) researchers and our experiences, those difficulties also present challenges for the production of design principles. This is evident in the statements of participants in this paper's design cycles who stressed hurdles in considering relevant project components early on, starting with a project, and collaborating. Against this backdrop, we set out to guide researchers through different areas of producing design principles. Following two genres of research questions (Thuan et al., 2019), we ask: *Which components define the production of design principles? How can the defining components be combined as a canvas-based tool for young researchers?*

As purposefully designed artifacts are useful to leverage education (Gill et al., 2022), this paper follows a DSR approach for building an educational tool. We draw from inquiry-based learning (IBL) and visual inquiry tools (Avdiji et al., 2020), which are well accepted for making complex design endeavors understandable and transferable. Visual inquiry tools (e.g., represented as a canvas) foster intuitive collaboration and help to reflect on how artifacts can be produced and published. For iteratively building our educational tool, the "Principle Constructor," we relied on scientific literature and an analysis of IS papers presenting design principles. For evaluation, we held a workshop with young DSR scholars in which we discussed typical challenges and derived possible refinements and conducted a single case study. With our work, we meet the challenges of making informed project choices, communicating (ongoing) DSR results, and considering important project components for design principles as a worthwhile outcome. By providing an outcome-specific tool, we help researchers to overcome difficulties in adapting methods to an individual situation (Winter & vom Brocke, 2021). Because visual inquiry tools can be combined with additional tools and methods, we see the Principle Constructor as a supplement to the DSR body.

Our paper is structured as follows: Section 2 outlines the underpinning educational approach and discusses the role of visual inquiry tools. Section 3 describes the research design. Section 4 illustrates our key findings, the Principle Constructor, initial guiding questions, and production patterns. Section 5 summarizes insights from the evaluation and demonstrates the tool's applicability. Section 6 presents implications and limitations, and Section 7 concludes the paper.

2. RESEARCH BACKGROUND

2.1 Inquiry-Based Learning for Design Science Research

Inquiry-based learning (IBL) is an approach to activate people (Pedaste et al., 2012). Instead of learning by consuming knowledge, IBL prompts students to apply methods and practices on their own to construct knowledge (Keselman, 2003). The effectiveness has been indicated by several scholars (e.g., Alfieri et al., 2011). By actively performing research, IBL follows the basic ideas of Dewey (1997), who emphasized that science should be taught as a process and way of thinking and not as a subject with facts. Referring to the DSR context, adjacent sub-streams of IBL have been developed, including design-based learning that integrates design thinking and design processes for the classroom (e.g., Goldkuhl et al., 2017; Kim et al., 2015).

In this paper, we employ IBL for DSR education for four main reasons, described in the following subsections.

2.1.1 Problem-Solving. DSR is a paradigm for solving real-world problems by creating useful solutions (Hevner et al., 2004; Thuan & Antunes, 2022). Prior literature provides evidence for the usefulness of problem-solving approaches in DSR education. For instance, Winter and vom Brocke (2021) have run a problem-oriented course for DSR over several years in which young researchers work on projects facilitating active experimentation and continuous reflection on their progress.

IBL is also viewed as an educational strategy to solve problems and thus fosters problem-solving skills (Pedaste & Sarapuu, 2006). In the first stage of IBL (i.e., orientation), young researchers should stimulate their curiosity about a specific problem. How those researchers tackle the problem may vary depending on their individual experiences, skills, and creativity level.

2.1.2 Design as a Search Process. Problems represent the difference between a goal state and a state at hand. Problem-solving is the search process to reduce this difference (Hevner et al., 2004; Simon, 1996). The process of finding solutions is inherently iterative and often unstructured (Chatterjee, 2015). Aspiring DSR researchers must become familiar with such challenging processes to solve problems in a given context. Consequently, young researchers should start early with conducting their DSR projects. Following Goldkuhl et al. (2017, p. 384), "IS education is learning about design but also learning through design." The relevance of actively engaging in their own projects is also emphasized by Winter and vom Brocke (2021), who argued that "action competence" is a critical element in enabling students to learn from their experiences.

IBL activates people and supports the idea of designing as a search process. The IBL procedure is characterized by activities (e.g., exploring a problem and solutions) that are performed iteratively across several "inquiry cycles" (Pedaste et al., 2012). With its activating learning focus, IBL responds to the need for "action competencies" in DSR education.

2.1.3 Adaption of (Research) Methods. DSR always happens in a specific context (Möller et al., 2022), which confronts researchers with adapting methods to a given situation. In addition to learning to follow methodological guidance, they must also acquire abilities to interpret methods in a context (Winter & vom Brocke, 2021).

IBL establishes experimental settings where methods can be applied to a specific context (Keselman, 2003). Students actively formulate hypotheses, perform experiments, test designs, and reflect on their results (Barrow, 2006; Pedaste et al., 2012). In doing so, they explore new knowledge and assess its relevance to the given research problem. Students learn by finding their individual path of solving a problem and adapting methods to a specific application setting.

2.1.4 Reflection and Communication. Learning DSR can be viewed as an inquiry process. An inquiry is a movement back and forth between the concrete and abstract (Goldkuhl et al., 2017). The inquiry process results in a dual outcome: The *direct and immediate outcome* that refers to the reconstruction of a situation by solving concrete problems (i.e., instance domain) as well as the *indirect and intellectual outcome* that refers to the conceptualization of learning (i.e., abstract domain) (Gregor et al., 2020; Miettinen, 2000). DSR education should not be only about conducting design exercises but also about creating meaningful design principles that connect a design product (concrete) with theorized design knowledge (Goldkuhl et al., 2017). Abstracting is, however, challenging and requires skills for reflection (Gregor et al., 2013; Schön, 1987) to collect experiences, re-assess them in a specific situation, and derive insights for future actions (Boud et al., 1985). Aspiring DSR researchers need to understand the role of reflection and train how to reflect. Besides individual reflection, it is especially for young researchers fruitful to collect feedback from others and discuss ideas to challenge the researcher's understanding (Winter & vom Brocke, 2021). To enable others (e.g., advisors and peers) to provide feedback, results and processes must be communicated (e.g., Schoormann et al., 2020). DSR students may use tools to reflect upon design decisions and activities.

Following the view of DSR as an inquiry process, the IBL approach also incorporates two constant activities of communication and reflection (Pedaste et al., 2012) and thereby fosters learning opportunities relevant to DSR education.

2.2 Visual Inquiry Tools

Young researchers must navigate through an unknown space because DSR typically deals with complex problems and is highly context-dependent. DSR is not only a paradigm to solve problems but also to reflect on the path of inquiry. Here, the class of visual inquiry tools comes into play. Such tools can support inquiry-based learners because they are useful for creative and problem-solving processes. They are well-suited for DSR education as they allow for joint inquiry, which can be defined as "a process through which a group of diverse individuals who face an uncertain situation jointly define and explore a problem, and jointly generate and evaluate different hypotheses about how to solve it" (Avdiji et al., 2020, p. 1). Given the power of visual inquiry tools for young researchers, they have been applied for numerous educational purposes (Boström & Sjöström, 2022), resulting in a diverse body of such tools represented as canvas, framework, scaffold, or map. Next, we summarize tools related to this paper's context.

2.2.1 Visual Inquiry Tools for Research. First, we found a class of tools for general research endeavors. For example, the *Research Design Canvas* (Ellway, 2019) provides a generic canvas to support Ph.D. students in planning their projects, and *MethodViz* (Boström & Sjöström, 2022) helps to establish an understanding of a research process with a focus on multidisciplinary work. Second, some tools suggest specific research methods, such as the *Search Canvas* (Schoormann et al., 2021), to plan literature reviews. Third, considering the importance of reflection, there are approaches to structure activities for reflection, like a *Prototyping Reflection Canvas* (Jobst et al., 2020).

2.2.2 Visual Inquiry Tools for DSR. Secondly, we found visual inquiry tools tailored to DSR. For example, the *DSR Grid* (vom Brocke & Maedche, 2019). A canvas-based solution that aims at presenting an overview of a DSR project as a one-pager, enabling a rather high-level communication. As another example, Morana et al. (2018a) proposed the *Design Canvas* to document and manage iterative DSR paths. Similarly, the *Design Research Canvas* (Nagle & Sammon, 2016) aims to support DSR projects but with a focus on encompassing stakeholders from practice and academia. Bringing together different perspectives, this canvas seeks to reduce misconceptions and conflicts.

2.3 Summary of Prior Literature and Research Objectives

Visual inquiry tools contain benefits for DSR education. They enable an individual way of interacting with the subject at hand. They open up new ways of communicating information visually and textually, which is especially helpful for creating shared understanding (John & Szopinski, 2018). Due to its flexibility (e.g., different components can be captured on one page and re-arranged during the DSR cycles), this class of tools supports problem-solving. As tools for joint inquiry, they are shaped for collaborative endeavors of (joint) reflection, enabling researchers to collect feedback and to participate in knowledge beyond individuals (e.g., advisors and peers).

However, although there is a valuable body of available tools, they tend to support DSR in general and may not be suited to specific settings. This is problematic because it hinders the execution of more contextualized DSR projects (Winter & vom Brocke, 2021) that, for instance, focus on producing specific outcomes, such as design principles. Consequently, given the generic nature of available tools, specific challenges (e.g., reflecting on relevant components to produce design principles) are not adequately addressed. Moreover, tools are often not explicitly developed to support novice researchers and thus do not take into account their specific challenges. This group typically prefers more guidance concerning the procedures, methods, and tools. With the *Principle Constructor*, we aim to provide a canvas-based tool that helps to communicate and reflect on the process and the product of design principles in a more contextualized fashion. We believe that particularly design principles serve as a valuable unit for our purpose because they already require some degree of abstraction from concrete projects and thus leverage reflective thinking.

3. METHOD: A DESIGN SCIENCE STUDY

DSR has been adopted to design educational tools (Blecher et al., 2022; Cahenzli, 2022) and visual inquiry tools for research (Morana et al., 2018b; Schoormann et al., 2021). Accordingly, we follow a procedure informed by Peffers et al.'s (2007) called *design science research methodology* (DSRM) allowing for iterative building and evaluating an artifact. Next, we describe how our paper operationalizes the methodology.

3.1 Problem and Objectives

For capturing the problem situation, we draw on three sources: First, the start of this paper's project was triggered by discussions among the author team concerning issues during the production of design principles. Hence, a reflection-driven approach was employed (Schön, 1983) to analyze our personal experience. In line with Gregor et al.'s (2020) problem formalization, this involved looking back through journeys of publishing design principles and jointly elaborating on issues of its production. Second, to collect empirical insights, we held a half-day online workshop with six Ph.D. students across different professional stages. While half of the group had already published design principles or were in the final stage of publishing them, the other half was at the beginning of their journeys. Third, we analyzed prior literature with methodological guidance on the production of design principles (see Appendix A).

Based on the multi-grounding, we were able to derive a series of challenges and needs, which we synthesized into four main clusters: (1) *Guidance* – demand for more specific guidance on design principles (Schoormann et al., 2023) to meet the challenges of adapting methods to a specific context (Winter & vom Brocke, 2021); (2) *The dilemma of starting* – researchers are overwhelmed by plenty of DSR project options (Smuts et al., 2022), components to be considered, as well as grounding strategies (e.g., theory, case studies, and expert interviews); (3) *The interplay between artifacts and design knowledge* – challenges in terms of translating knowledge into situational artifacts and vice versa; and (4) *Collaboration and feedback* – need to communicate results and establish a shared understanding of DSR projects to get feedback.

To overcome the challenges, we created a visual inquiry tool (Avdiji et al., 2020). We believe a visual inquiry tool is fruitful for design principles, especially to allow communication of (interim) results with all stakeholders, plan and reflect on important project decisions before and during a design project, and address the iterative nature of producing design principles.

3.2 Design and Development

We began conceptualizing available knowledge relevant to the design principle production by reviewing articles (Webster & Watson, 2002) that present design principles. Our search strategy strives to collect a representative sample that provides insight into how design principles are produced and published. We build the sample consisting of high-quality papers from journals and conferences. We adopted the sample from Gregor et al. (2020) to obtain journal articles. Additionally, we completed this by using *AISeL* and *Scopus* to search for papers in the proceedings of *ICIS*, *ECIS*, and *DESRIST*. We used the keyword "design principle" in the title and abstract to find relevant papers. Then, each paper's full text was screened, and those papers that did not explicitly report design principles were removed. Based on a sample of 156 papers (collected in 2021), we created a randomized subsample of 20 journal articles and 40 conference papers to have a manageable set of publications (see Appendix B for a list of publications). This serves as the foundation for deriving fundamental components of the design principle production.

Two researchers analyzed each paper using a priori-defined coding scheme. The initial codes stem from our experience in design principle production and include a knowledge base, evaluation techniques, and descriptions of situational instantiations. We refined the coding scheme during the analysis of the sample. After about two-thirds of the selected papers, no new components could be identified, pointing to a theoretical saturation.

To assemble our visual inquiry tool, we followed the guidelines from Avdiji et al. (2020) (see Appendix C). In doing this, we (1) crafted the Principle Constructor tool. The initial version of the tool was grounded in the synthesis of the codes collected during the literature analysis in combination with deductive reasoning (i.e., drawing from methodological literature, see Appendix A); a previous version of the Principle Constructor was published in Möller et al. (2021). In Table B1, exemplary codes and references are provided for each of our tool's components. Additionally, we (2) abductively developed an initial catalog of guiding questions to inform the tool's use as well as (3) drew on previously published principle production strategies (Schoormann et al., 2021) to create preliminary patterns that describe how to start and proceed with the tool (i.e., "directions for use" from Avdiji et al., 2020).

3.3 Demonstration and Evaluation

Two evaluation episodes were conducted (Venable et al., 2016). First, we held a workshop with six Ph.D. students to examine the tool's usefulness; three students had already published design principles and retrospectively discussed/used our tool. The other students were at the beginning of a design project. Having a heterogeneous group enabled us to gather a broader range of feedback. After giving a short introduction and discussing typical challenges within the group regarding design principle production (e.g., problem recognition), we asked the participants to rate the component candidates extracted from the literature analysis. Based on the evaluation results, we investigated the (a) relevance of the components (i.e., are all relevant components captured by our tool?), (b) understandability of the components (i.e., are the titles easy to understand?), and (c) the structure (i.e., arrangement within the visual inquiry tool).

Second, after refining the tool, a real-world use case is reported. In that case, a young researcher not involved in the artifact used the tool over several months to organize an academic-practice project for blockchain-based systems.

4. ARTIFACT DESCRIPTION

Our solution contains a visual inquiry tool (canvas) and an initial catalog of guiding questions and production patterns.

4.1 The Principle Constructor

Based on our understanding of producing design principles, the analysis of IS papers reporting design principles, and our evaluation with young researchers, we now present the

"Principle Constructor" (see Figure 1). Our visual inquiry tool comprises 16 components arranged across four major and interrelated areas for *foundation and grounding*, *problem and goal*, *solution*, as well as *design and evaluation*. We decided to incorporate a comprehensive number of components compared to other visual inquiry tools to provide more guidance and choices to be reflected. This was also requested during the evaluation. We apply a color-coding informed by common color pallets to differentiate the areas easily.

4.1.1 Constructor Header. The tool header is intended to capture basic information about the project, including the project *title*, the *date* of production, and the *version*. While there is typically an evolution of the design principles across a project, versioning helps to trace changes. Researchers might want to report the entire process, from initial design principles to more mature design principles, by highlighting differences and their justifications (e.g., advisor feedback).

4.1.2 Foundation and Grounding. The input knowledge for a project needs to be clarified, wherefore we differentiate *theoretical* and *empirical grounding*. Following Iivari (2015) and Schoormann et al. (2022), the grounding of design principles follows either a bottom-up approach to draw on empirical data (e.g., engraved in use cases, artifacts, documents, and experts) or a top-down approach in which principles build upon a theoretical foundation (e.g., kernel theories explaining why the prescriptive design knowledge should work, Walls et al., 1992). In line with knowledge accumulation and evaluation, the theoretical-driven approach can draw from existing design principles or general design knowledge to develop new or extended design principles (see also Section 4.3).

4.1.3 Problem and Goal. This area covers the problem space and differentiates between *specific problems* and the more abstract *problem class* as well as, from a solution viewpoint, between *solution objective* and *design requirement*. We can observe substantial heterogeneity in the terminology used to describe those elements in our sample, for instance, key challenge, design requirement, user requirement, and meta-requirement. That differentiation is usually associated with a dichotomy between theory-driven and practice-driven research. For instance, action design research (ADR) projects typically derive design knowledge from specific cases (Sein et al., 2011). Although the term meta-requirement is often used for requirements derived from theory and design requirements from empiricism, our tool refers to design requirements to represent both types.

Regarding the goal of a DSR project, papers frequently report research questions to guide their endeavors. Based on the analysis, we obtained three types of questions:

- *Principle-driven questions (what)* to particularly focus on the design principles as an outcome; for example, "[what] are the appropriate design principles for an analytics system that affords wildlife management?" (Pan et al., 2020, p. 1).
- *Requirements-driven questions (what)* to derive basic requirements as the first step towards design principles; for example, "[what] are the meta-requirements of digitized industrial products in the industrial service business?" (Herterich, 2017, p. 365).
- *Design-driven questions (how)* to emphasize the larger design project, including several outcomes from instantiations to design theory; for example, "[how] can we develop visual inquiry tools for specific strategic management problems?" (Avdiji et al., 2020, p. 696).

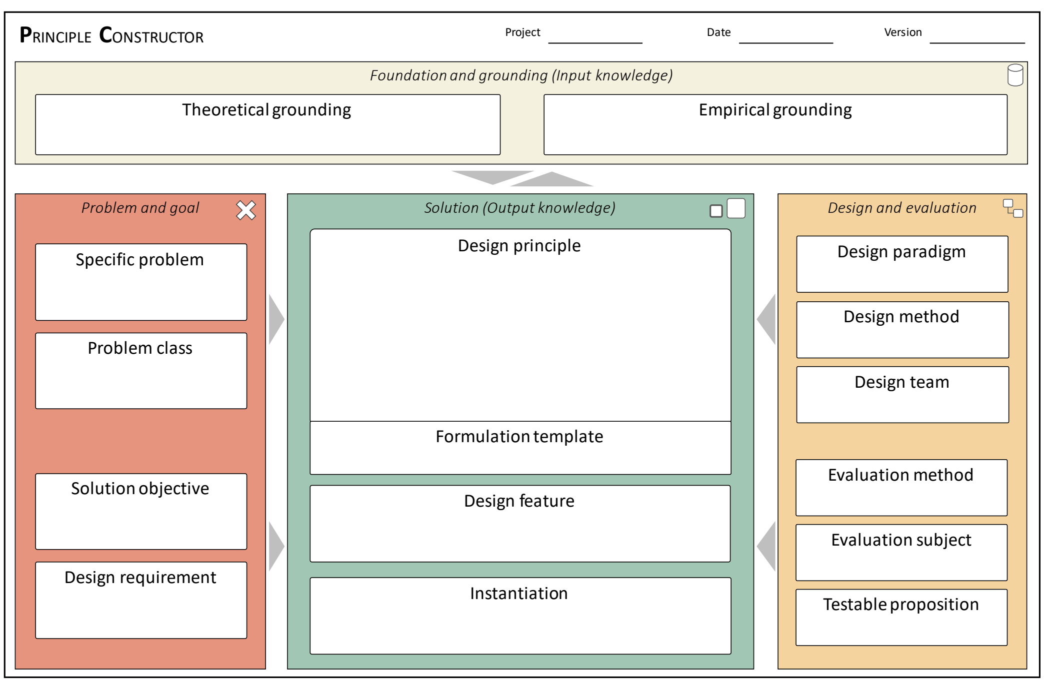


Figure 1. The Principle Constructor

4.1.4 Design and Evaluation. This area comprises components for building and evaluating design principles. The *design paradigm* describes the underlying strategy to develop design principles. Next to ADR (Sein et al., 2011), the two dominant DSR approaches in our sample are from Kuechler and Vaishnavi (2008) and Peffers et al. (2007). For evaluation, papers draw on the rich body of DSR methods (Venable et al., 2016) and use, for example, instantiations, focus groups to discuss the expected usefulness with practitioners, and case studies. Subsequently, the *evaluation method* refers to "how" the design principles are evaluated, and the *evaluation subject* specifies with and for "whom." *Testable propositions* refer to short statements that guide the user of design principles to be tested (typically) against the meta-requirements.

4.1.5 Solution. The heart of the Principle Constructor focuses on the output (knowledge) and distinguishes between four common components. *Design principles* address the requirements and goals. Some authors use pre-defined *templates* to formulate their principles (e.g., Cronholm & Göbel, 2018; Gregor et al., 2020). To guide how to operationalize design principles, studies provide *design features* (e.g., Meth et al., 2015) that bridge the gap between abstract knowledge and concrete implementations. At the most situational level, the *instantiation* component captures specific implementations, such as software prototypes (Schoormann et al., 2020).

4.2 Catalog of Guiding Questions

Following Avdiji et al. (2020), directions for using a visual inquiry tool need to be provided, such as in the form of articulated questions. Therefore, we present a catalog of "guiding questions" (see Figure 2) that can be answered during the use of the Principle Constructor. They are intended to prompt actions and reflections as well as support the actual meaning of components.

4.3 Preliminary Production Patterns

In addition, we aimed to present a more process-oriented view of the directions of use. Therefore, we draw on design principle configurations from Schoormann et al. (2022) and highlight how they can be adopted by the Principle Constructor. As a result, four initial production patterns with different aims and entry points were created (see Figure 3).

The *theory-driven production* ***(E1)*** of design principles follows a top-down approach and thus conceptualizes theoretical knowledge as design requirements and/or principles. In subsequent steps, to evaluate the design principle's applicability and usefulness, they are translated into more specific implementations, such as design features and situational instantiations. After several iterations of refinement, the final set of principles is communicated.

Area	Component	Exemplary guiding questions
Problem and goal	Specific problem	• What is the actual problem (situation) to be addressed with design principles? • Which use case or scenario raises the specific problem?
	Problem class	• To which abstract class of problems does a specific problem belong? • Are there relationships between the specific problem to other problems?
	Solution objective	• Does producing design principles help to solve a problem (class)? • For whom (target user) are design principles important?
	Design requirement	• Which are the main requirements and needs for a solution? • From what sources can the requirements be extracted?
Foundation (Input knowledge)	Theoretical grounding	• Which (kernel) theories can inform the production of design principles? • Is there available design knowledge that can be (re-)used?
	Empirical grounding	• Which empirical sources can be used to inform the production of design principles? • What data is available and can be (re-)used to inform the production of design principles?
Design and evaluation	Design paradigm	• What is the underpinning research paradigm (ADR/DSR) for producing design principles? • How to enter the overall process (development strategy) for producing design principles?
	Design method	• Which basic structure (procedure model) can be followed to produce design principles? • Which (research) method can be used and why?
	Design team	• Who develops the design principles (academic/practice)? • What experts can be consulted to get feedback on the design principles?
	Evaluation method	• What quantitative and/or qualitative methods can be used to evaluate the design principles? • What are the potential benefits and shortcomings of an evaluation method?
	Evaluation subject	• Which are the main target user groups of the design principles (e.g., practice vs. academia)? • Who is able to evaluate the design principles and why?
	Testable proposition	• What are the effects occurring from using a solution that follows the design principles? • How can an effect be tested and/or measured?
Solution (Output knowledge)	Design principle	• What is the intended design principle's level of abstraction? • Which class of artifact do the design principles address?
	Formulation template	• How can the design principles be formulated? • Which design principle anatomy components are addressed?
	Design feature	• How can the design principles be operationalized? • What is needed to further guide the operationalization of the design principles?
	Instantiation	• What are exemplary instantiations of the design principles? • How does an instantiated artifact that follows the design principles look like?

Figure 2. Initial Guiding Questions

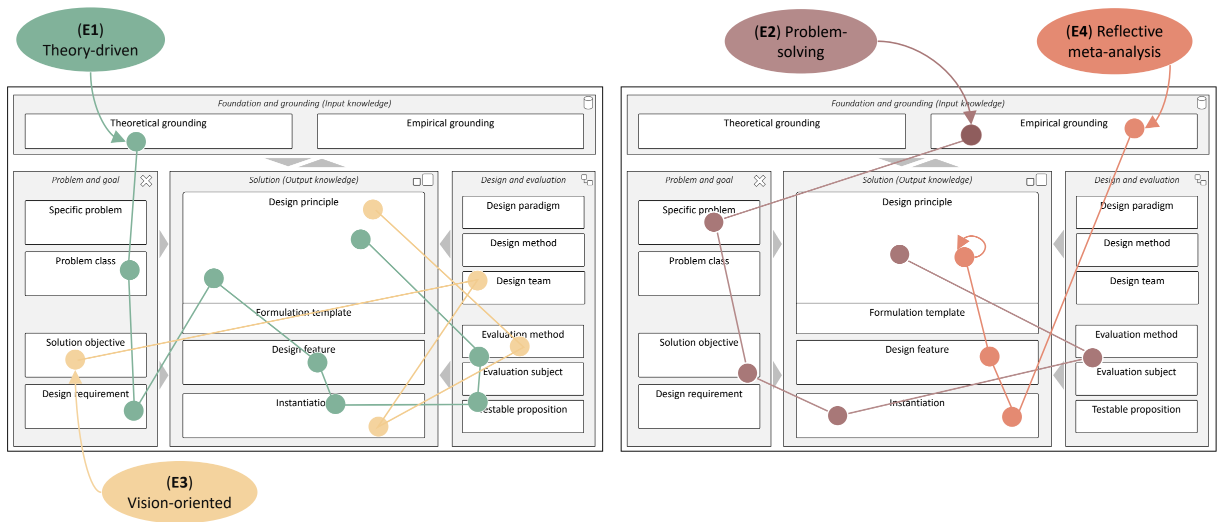


Figure 3. Preliminary Design Principle Production Patterns (based on Schoormann et al., 2022)

Contrary to top-down, *problem-solving production (E2)* begins with collecting and analyzing empirical data (e.g., expert interviews and document analysis) to formulate a problem situation. Having a specific problem and related objectives, a concrete instantiation of an artifact is created. The instantiation is then evaluated and refined iteratively until the artifact's usefulness is achieved. In the final stage, researchers reflect on the design process and product to abstract knowledge. Comparable to that, the *vision-oriented production (E3)* also employs a bottom-up approach, which is often informed by the researcher's curiosity to investigate novel phenomena or explore ideas. Typically, those projects start with discussing ideas within the design team and moving quickly toward the design of situational implementations. Those serve as a unit for evaluating and abstracting design knowledge. Lastly, *reflective meta-analysis (E4)* is characterized by retrospect in which researchers reflect on projects to formalize knowledge ex-post or integrate different studies to arrive at a more general level of design principles.

5. DEMONSTRATION AND EVALUATION

5.1 Workshop for Understandability and Relevance

In the first episode, we investigated the relevance of the components and the structure of the visual inquiry tool through a workshop with DSR researchers. In addition to collecting qualitative insights throughout the discussions, we provided the participants with a five-point Likert scale (1 not agree to 5 agree) to rate the component's importance for producing design principles. As a result, several components were rated as highly important, with an average of over 4.3, including design requirement, solution objectives, formulation template, underlying paradigm, development method, and evaluation method; an overall average value of 4.05 (see Appendix D).

By drawing on our memos from the discussion session, we found multiple pieces of evidence for the relevance and expected usefulness of the Principle Constructor. For instance: *The tool will be beneficial in the early stages to creatively and jointly plan design projects with different stakeholders from both academia and practice; appreciate the idea of building blocks that show what are the main components to be considered in a design project; a canvas provides a nice overview for both practitioners and researchers* (communication); *will be particularly helpful for the planning and ideation phase*. Also, the participants highlighted the kit-inspired functionality of our tool that *helps young researchers to reflect on important decisions, such as selecting methods and theories* and *getting impulses* on what components should be considered.

5.2 Use Case for Blockchain-Based Systems

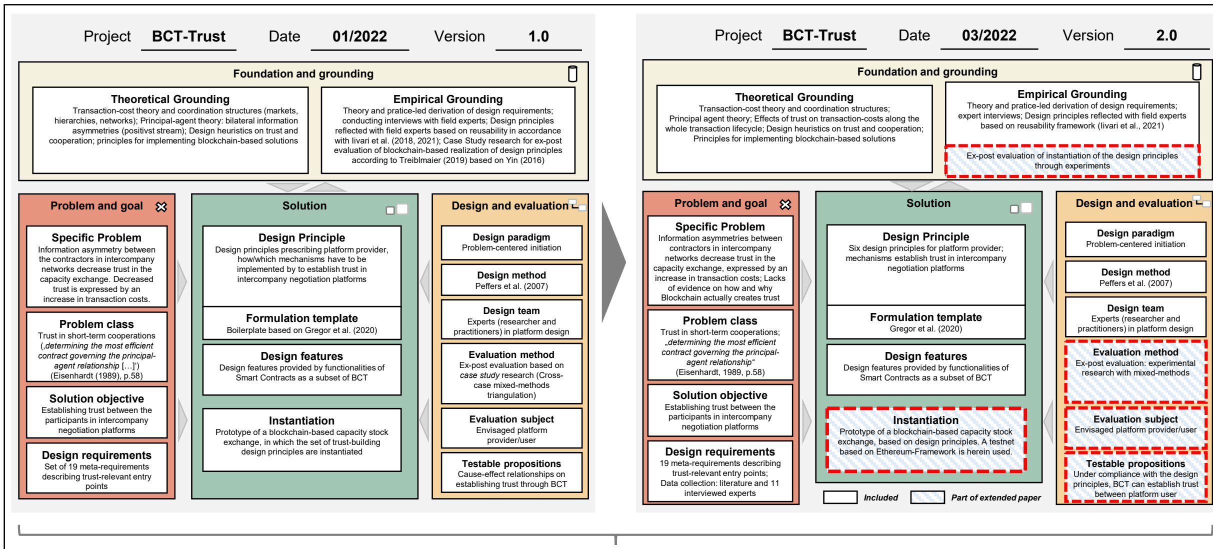
Moreover, we conducted a case study in which a Ph.D. student applied the tool over several months to manage a DSR project. Afterward, the student performed a written reflection in which benefits and challenges were disclosed from the actual use.

5.2.1 Case Description. The case concerns designing a blockchain-based artifact to establish trust in intercompany capacity exchange. The DSR project addresses problems caused by uncertainties through information asymmetries between stakeholders within electronic negotiation platforms. Although there is a growing body of literature on the potential of blockchain in decentralized markets, it remains unclear how and why it establishes trust. Therefore, the research team (Ph.D. student, research assistant) developed a situational artifact as well as design principles for reducing information asymmetries. As prior research called for a more theoretical grounding of blockchain research, the researchers decided to use the Principle Constructor as a guiding tool.

5.2.2 Application Process. In the project, the Principle Constructor was applied for the first time after an initial set of design principles was formulated. The principles needed to be communicated to peers (e.g., advisors) to obtain feedback and plan the next steps. The overall project started with a specific problem situation, for which reason the researchers filled in the problem-related components first, followed by the specification of the solution objective. Problem and solution are informed by selected theoretical lenses, i.e., theoretical grounding. The Constructor was used during (a) an internal Ph.D. workshop with the supervisor and other researchers and (b) a conference presentation, in which the progress of the overall project was reported, and the remaining steps were discussed. Based on the Constructor-driven discussions, the researchers changed the evaluation approach from case studies to subject-related experiments (see Figure. 4), followed by a pretest-posttest design. The modularity of the Constructor allowed for refining certain components during ongoing discussions, which was recognized as useful.

5.2.3 Lessons Learned. By reflecting on the Principle Constructor's application, several benefits and challenges could be extracted. First, the tool helped structure and condense the overall DSR project, characterized by several iterations and adjustments that need to be reflected and traced back (reflection). It helped to position the project within a problem-centered design process. It should be mentioned that it does not fully prescribe where to start but offers several entry points, which improves its flexibility. Second, the tool contributed to the transparency of the entire DSR journey of the blockchain project. For example, it allows communication whether the project is dealing with the design of a blockchain-based artifact or a blockchain-based implementation of a technology-independent artifact (communication). For that reason, the tool helped report an understandable state of the project, opening discussion opportunities. Third, the filled-in visual inquiry tool can be used as a momentum of a work-in-progress and provides many decoupling points to rethink how the course must be set for the follow-up step (learning through design). Hence, it facilitates joint planning of the next steps based on a project's status quo.

Fourth, while it helps to structure design principle projects, it does not replace established DSR tools (interpret methods in a context). It can be seen as an addition. For example, researchers can use additional guidance to fill out evaluation components (e.g., Venable et al., 2016). Moreover, based on an underpinning configuration, the sequence of filling out the components can vary. With the tool, researchers are prompted to question how and why the components are important for their research. Fifth, challenges occurred due to the "nature" of the visual inquiry tool. For instance, the researchers argued for limited space within the components of the tool as well as differences between rather fixed components (e.g., formulation templates) and varying components that frequently change across the project. By storing different tool snapshots, those changes can be visualized. However, a single snapshot does not highlight the project's evolution. Sixth, researchers should be aware that just filling out the components does not (automatically) lead to an appropriate research design. It is intended to reflect on aspects and make informed decisions.



(Initial) Design principles for establishing trust in decentralized capacity exchange

DP1	Signaling of Information relevant to Tender	To allow demander and supplier (**U**) the storage of a precise tender (**A**) during the specification stage (**C**), the platform provider or developer (**I**) has to provide functions for a customized creation of tenders and its linkage to a verified identity and reveal them in a simultaneous and distributed manner (**M/E**). This allows the reduction of uncertainties due to a vague specification and lacks identity assignments, simultaneously providing the revealing of information to authorized participants (**R**).
DP2	Signaling of Information relevant to Identity	To establish trust in the identity (**A**) of each participant (**U**) during the information and initiation stage (**C**), the platform provider or developer (**I**) has to provide functions for the decentralized storage, configuration, and verification of identities (**M/E**). This allows transparency and correctness of the identity (**R**).
DP3	Authority and Fairness	To maintain the authority (**A**) of the cooperation partner (**U**) before and after the negotiation and settlement stage (**C**), the platform provider or developer (**I**) has to provide functions and mechanisms for creating and decentralized storage of contracts as well as their order-relevant contents, functions for monitoring the compliance with the agreed terms and conditions for enforcing sanctions/rewards (**M/E**). This provides a transparent data basis for all participants, as well as traceability in the enforcement of countermeasures (**R**).
DP4	Incentive-Mechanisms	To motivate the participants (**U**) in joining and maintaining cooperation before and after the negotiation and settlement stage (**A**), the platform provider or developer (**I**) has to pro-vide the value-adding benefits of each cooperation and imminent losses in case of violations and demonstrate them using comprehensible and transparent data that can be observed by all participants (**M/E**). In this way, market participants are motivated to participated and deterred from acting opportunistically (**R**).
DP5	Screening-Functionality	To ensure that the participants of the negotiation platform (**U**) can trust the deposited information (**A**) during the information and initiation phase (**C**), the platform provider or developer (**I**) has to provide functions for depositing information and for distributed and verified access, functions for checking its validity and services for searching information and contacting participants (**M/E**). This ensures that the information obtained during the information retrieval are valid and thus trustworthy (**R**).
DP6	Reputation Mechanism	To achieve a retraceable reputation (**A**) of each participant (**U**), the platform provider or developer (**I**) has to provide a reputation mechanism (**M**), which allows after the fulfillment stage (**C**) a serious rating of each identity, a decentralized collection of rating-relevant data, its transparent processing and distribution to all participants (**E**). In this way, participants have transparency over the data coining the reputation, and can trust them (**R**).

Notes: left = version 1; right = version 2 (after getting feedback); red boxes = revisions.

Figure 4. Application of the Principle Constructor (based on Große, 2022)

6. DISCUSSION

Inquiry-based learning (IBL) activates students to engage and perform in (real-world) research projects to solve problems and construct knowledge on their own (Pedaste et al., 2012). IBL prompts students to apply problem-solving skills, find solutions across several inquiry cycles, cater abstract methods and tools to a specific situation, and learn to jointly reflect on processes to generalize knowledge. These learning aspects are also relevant for DSR education (e.g., Goldkuhl et al., 2017; Winter & vom Brocke, 2021). By drawing on the idea of IBL and aiming to respond to the problems collected from young researchers, this study presents a visual inquiry tool for producing design principles. We focus on design principles because they are important outcomes of DSR projects and pose specific challenges to young researchers concerning knowledge abstraction. Our solution is the Principle Constructor and an initial catalog of guiding questions and production patterns.

6.1 Implications for (Educational) Practice and Research

Our work has several implications. First (guidance), we consider the need for additional guidance and the "dilemma of starting" identified from our problematization by providing contextualized guidance for producing design principles. Our tool enables researchers to start with DSR projects and actively create design principles. Like in DSR projects in general, there are many ways to produce design principles. However, the Principle Constructor is particularly inspired and tested in settings with young researchers, thereby considering their needs, such as a more comprehensive overview of components to be reflected. It serves as a checklist with items that require informed decision-making.

Second (communication), in line with IBL, our visual inquiry tool facilitates intuitive communication and sharing of projects with others. The evaluation indicates that researchers were supported in presenting their DSR projects to others (e.g., advisors, peers, reviewers) to obtain feedback and plan future steps. A shared understanding needs to be established among a diverse group of stakeholders as a prerequisite for this. The Principle Constructor fosters accessibility through the representation of projects in a visual and textual manner. Besides young researchers, this also opens up reporting opportunities for more experienced scholars.

Third (reflection and abstraction), young researchers in our workshops stressed hurdles concerning the interplay between artifacts and abstract design knowledge. Generalizing knowledge from concrete situations requires abilities to reflect. By filling out the tool, researchers start actually doing something, which triggers opportunities for reflection-in-action and reflection-on-action (Schön, 1983; Schoormann et al., 2020). These can be conducted individually but also jointly with a team.

Fourth (flexibility), the Principle Constructor implements common benefits from general visual inquiry tools. Contrary to rather fixed methods and tools, the Constructor leverages flexibility by allowing users to freely fill out, discuss, and refine certain components. While the tool has some conceptual borders for producing design principles, it still enables users to handle it flexibly (see also lessons learned from the use case). By making several snapshots over the time of a project, the individual journey can be captured, which contributes to the overall transparency.

Lastly (combination), the Principle Constructor is not intended to replace available guidance but add a comprehensive and easy-to-use tool for producing design principles. As shown in the case evaluation, the components still require researchers to select more concrete techniques. Here, we see different integration potentials depending on the abstraction level of a tool: Our tool allows for combinations with more specific techniques in each component, such as for formalizing the problem (e.g., Herwix & Haj-Bolouri, 2021), grounding the design knowledge (e.g., Goldkuhl, 2004), formulating DSR research questions (e.g., Thuan et al., 2019), and evaluating the design principles (e.g., Iivari et al., 2020). Vice versa, our tool can serve as an input for more generic tools, such as the DSR Grid that captures "output knowledge" (vom Brocke & Maedche, 2019) or the Design Canvas that presents "design knowledge" as an outcome (Morana et al., 2018b). With its focus on design principles, the Constructor is contextualized to a specific outcome in contrast to other more generic DSR tools and serves as a holistic presentation combining both elements of the process and the product of a DSR project.

6.2 Limitations and Outlook

Naturally, our findings have limitations, opening avenues for future research. While we incorporated knowledge from researchers, there is room for additional evaluation and testing. For instance, although we were able to show the tool's usefulness via a case study, this only covers a single study and should be repeated with other scholars. Also, although we collected quantitative and qualitative data from our workshop session with six students, the quantitative data has limited statistical relevance. The title of the components is based on a consensus among the authors and the experiences collected during the evaluation. However, given the heterogeneous landscape of research within the DSR community, other scholars might prefer a different terminology (e.g., meta vs. design vs. user requirement) and even additional or other components. The guiding questions are also based on their own interpretations from analyzing the papers and the production patterns from deductive reasoning. However, when using the Principle Constructor more frequently, we plan to explore additional patterns of usage and evolution paths.

7. CONCLUSION

While DSR has the potential to contribute to societal and environmental challenges, teaching DSR methods and tools tends to be underrepresented in today's curricular and education concepts. In this paper, we advance DSR education by presenting a visual inquiry tool in the form of a canvas for one of the prevailing types of design knowledge, namely design principles. Design principles can bridge multiple DSR outcomes, such as meta-requirements (goals), design features (technical-oriented formalizations), and instances (artifacts), for which reason we believe that they present a valuable unit for research. Nonetheless, abstracting knowledge obtained throughout a project is challenging, and novices can be easily overwhelmed by the number of choices to make in the early project stages. The Principle Constructor is intended to be easy to use and share to enable others to provide feedback and participate in projects. The tool serves as a project repository that can accompany researchers across several weeks, months, or even an entire Ph.D. program. The evaluations indicate auspicious results, especially in supporting young researchers to produce, communicate, and reflect on design principles jointly.

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APPENDICES

Appendix A. (Selected) Methodological Literature on Design Principles

During the lifecycle stages of producing design principles, different approaches proposed in the literature can be used to inform our artifact:

- **Grounding** (Goldkuhl, 2004) – researchers can rely on input knowledge from a more theoretical viewpoint (e.g., kernel theories) to a more empirical level (e.g., expert interviews).
- **Development strategies** (Schoormann et al., 2022) – for instance, in case empirical data is available, a bottom-up approach is followed in which a specific problem is solved first and design principles are extracted in the later phases of the project; in case a theory is chosen, a more top-down approach is employed in which design principles are conceptualized based on theoretical knowledge and then implemented in an artifact.
- **Formulation templates** to communicate knowledge (e.g., Cronholm & Gröbel, 2018). Among the prevailing templates is Chandra Kruse et al., (2015): "Provide the system with [material property—in terms of form and function] in order for users to [activity of user/group of users—in terms of action], given that [boundary conditions—user group's characteristics or implementation settings]".
- **Evaluation** – Iivari et al. (2020) presented a framework: easy to understand and implement (*accessibility*), represent important design elements (*importance*), communicate something new (*novelty and insightfulness*), be feasible and implementable (*actability and guidance*), and positively influence the design of an artifact (*effectiveness*).

Appendix B. Design and Development – Derivation of Visual Inquiry Tool Components

The following figure shows how the coded items from the literature analysis were synthesized to arrive at our Principle Constructor components.

Our tool (Principle Constructor)		Coded items	Exemplary references from our sample	*Avg. rating (see above)*
Foundation	Theoretical grounding	Kernel theory *(e.g., Sensemaking #9 #106; Reflection #7 #9; Principal agent #14; Collaboration #23; Affordance #27 #103 #106; Persuasive systems #136; Cognitive efficiency #145; Social action theory #153; Organisational learning #153)*	#9 #102 #133	*4.33*
		Theoretical propositions	#3 #14 #26	
		Theoretical frameworks/models (e.g., *Toulmin's Model*)	#31	
		Theoretical lenses	#106	
	Empirical grounding	Interview data *(e.g., from experts #38; users #10; industry partner #6)*	#1 #29 #28 #8 #38 #10 #20	*4.50*
		Use cases, design projects	#22 #17 #22 #134 #127	
		Document analysis, market reviews, internet	#1 #5 #30	
		Existing artifacts *(e.g., software tools #9)*	#9 #15	
		Expierence/knowledge from design team	#12 #23 #32	
		Scientific literature	#1 #8 #22 #29 #124 #135	
	Both	Previous/available design principles (reuse)	#18 #23 #110 #145 #136	---
Problem and goal	Specific problem	Description of situation/use case	#2 #8	*4.00*
		Practical problem	#6	
	Problem class	Class of problems	#3 #4	*4.00*
	Solution objective	Solution objectives	#27	*3.83*
		Solution design	#8	
		Design goals	#17 #26	*4.33*
		Class of systems addressed	#13	
	Design requirement	Design requirements	#3 #6 #135	*3.67*
		Key challenges	#36	*3.83*
		User stories, user requirements	#10 #28	---
		Issues	#2 #5 #13 #25 #28	*3.83*
		Meta requirements	#5 #9	*4.33*
		Design problem	#133	---
Solution	Design principle	Design principles	#1 #5 #135	*4.83*
	Formulation template	Templates *(e.g., Chandra Kruse et al. 2015 #3 #103 #106; Legner & Löhe 2012 / Meth et al. 2015 #26; Gregor et al. 2020 #34)*	#3 #103 #106	*4.50*
		Design accumulation and formalization	#127	---
	Design feature	Design feature	#3 #6 #9 #25 #135	*3.60*
		Design component	#38	---
	Instantiation	Artifact	#1	*3.17*
		Software prototype	#7 #9	
		Framework	#11	
		Process	#30	
		Web application process	#32	

Our tool (Principle Constructor)		Coded items		Exemplary references from our sample	*Avg. rating (see above)*
Design and evaluation	Design paradigm	Design science research	Hevner 2007	#10 #28	*4.50*
			Kuechler & Vaishnavi 2008	#6 #9 #13 #15 #20 #31 #36 #38	
			Kuechler & Vaishnavi 2012	#14	
			Kuechler & Vaishnavi 2004	#29	
			Kuechler & Vaishnavi 2015	#34	
			Kuechler et al. 2009	#38	
			Peffers et al. 2007	#5 #25 #27 #30 #40 #102 #106 #135 #151	
			Meth et al. 2015	#6 #135	
			Nunamaker et al. 1990	#151	
		Action design research	Sein et al. 2010	#8 #12 #139	
			Mullarkey et al. 2019	#103	
	Design method	Heuristic theorizing (Gregory & Muntermann 2014)		#4 #139	*4.33*
		Design thinking-inspired		#139	
		Reflection and abstraction		#1 #12 #15 #32#138 #127	
		Deduction / theory-driven derivation		#14 #133	
		Grounded theory		#26	
		Case study		#136	
	Design team	Design principle developer		#3	*4.00*
	Evaluation method	Building artifact, instantiation, demonstration, illustrative scenario		#1 #10 #11 #20 #106 #135 #139 #144 #148 #38	*4.50*
		Prototype evaluation		#5 #13	
		Applicability (Rosemann & Vessey 2008)		#17	
		Interviews		#17	
		Use cases		#22 #29 #135	
		Focus groups		24 #26 #106	
		User study		#27	
		Analytic hierarchy process method		#39	
		Case study		#102 #106	
		Field study		#151	
		Practice workshops		#103	
		Experiments with prototype		#133	
	Evaluation subject	Students		#1	--
		Industry experts		#24 #26	
	Test. proposition	Testable design propositions		#35 #133 #139 #144	---

Figure B1. Mapping of Tool Components with Codes and Empirical Rating

Next, we present the **journal articles (n = 20) and conference papers (n = 40)** that we randomly selected for creating our sample of 60 articles. The original sample captures a total of 156 papers.

ID	Authors	Title	Journal
102	Nguyen et al. (2020)	Design principles for learning analytics information systems in higher education	EJIS
103	Pan et al. (2020)	Sustainability design principles for a wildlife management analytics system: An action design research	EJIS
106	Seidel et al. (2017)	Design principles for sensemaking support systems in environmental sustainability transformations	EJIS
110	Fahmideh et al. (2019)	A generic cloud migration process model.	EJIS
112	Lange et al. (2016)	An empirical analysis of the factors and measures of Enterprise Architecture Management success.	EJIS
123	Wong et al. (2012).	Artificial immune systems for the detection of credit card fraud: an architecture, prototype and preliminary results	ISJ
124	Granados et al. (2010)	Research commentary—information transparency in business-to-consumer markets: concepts, framework, and research agenda. Information Systems Research	ISR
127	Avdiji et al. (2020)	A design theory for visual inquiry tools	JAIS
133	Arazy et al. (2010)	A theory-driven design framework for social recommender systems	JAIS
134	Bygstad (2017)	Generative innovation: A comparison of lightweight and heavyweight IT	JAIS
135	Chanson et al. (2019)	Blockchain for the IoT: Privacy-preserving protection of sensor data	JAIS
136	Corbett (2013)	Designing and using carbon management systems to promote ecologically responsible behaviors.	JAIS
138	Eriksson & Ågerfalk (2010)	Rethinking the Meaning of Identifiers in Information Infrastructures	JAIS
139	Janiesch et al. (2019)	An Information Systems Design Theory for Service Network Effects.	JAIS
144	Müller-Wienbergen et al. (2011)	Leaving the beaten tracks in creative work–A design theory for systems that support convergent and divergent thinking	JAIS
145	Parsons & Wand (2013)	Extending classification principles from information modeling to other disciplines	JAIS
146	Soffer et al. (2015)	Conceptualizing routing decisions in business processes: Theoretical analysis and empirical testing	JAIS
148	Twyman et al. (2020)	Design Principles for Signal Detection in Modern Job Application Systems: Identifying Fabricated Qualifications	JMIS
151	Silic et at. (2019)	Using Design-Science Based Gamification to Improve Organizational Security Training and Compliance	JMIS
153	Kolkowska et al. (2017)	Towards analysing the rationale of information security non-compliance: Devising a Value-Based Compliance analysis method	JSIS

Table B1. Subsample of Selected Journal Articles (n=20)

ID	Authors	Title	Conf.
1	Karunakaran et al. (2012)	Designing for recombination: Process design through template combination	DESRIST
2	Lempinen et al. (2012)	Design principles for inter-organizational systems development - Case Hansel	DESRIST
3	Hönigsberg (2020)	A Platform for Value Co-creation in SME Networks	DESRIST
4	Döppner et al. (2016)	Exploring Design Principles for Human-Machine Symbiosis: Insights from Constructing an Air Transportation Logistics Artifact	ICIS
5	Meier et al. (2019)	FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness	ICIS
6	Li et al. (2017)	Designing a peer-based support system to support shakedown	ICIS
7	Schoormann (2018)	Design principles for leveraging sustainability in business modelling tools.	ECIS
8	Herterich (2017)	On the design of digitized industrial products as key resources of service platforms for industrial service innovation	DESRIST
9	Schoormann et al. (2018)	The Noblest Way to Learn Wisdom is by Reflection: Designing Software Tools for Reflecting Sustainability in Business Models	ICIS
10	Wambsganss & Rietsche (2019)	Towards Designing an Adaptive Argumentation Learning Tool	ICIS
11	Pöppelbuss & Roeglinger (2011)	What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management	ECIS
12	Grytz et al. (2020)	Business intelligence & analytics cost accounting: An action design research approach	ECIS
13	Benke (2020)	Towards Design Principles for Trustworthy Affective Chatbots in Virtual Teams	ECIS
14	Gröger & Schumann (2014)	Managing third-party funding projects at German state universities – A theoretical deduction of design principles for implementing an IT-artifact	ECIS
15	Vaishnavi et al. (2009)	Towards design principles for effective context-and perspective-based web mining	DESRIST
16	Schjerlun et al. (2018)	Design principles for room-scale virtual reality: A design experiment in three dimensions	DESRIST
17	Hoffmann et al. (2017)	Balancing alignment, adaptivity, and effectiveness: Design principles for sustainable IT project portfolio management	ECIS
18	Niemi & Laine (2016)	Competence Management System Design Principles: Action Design Research	ICIS
19	Fischer et al. (2020)	Critical Design Factors for Digital Service Platforms - A Literature Review	ECIS
20	Fegert et al. (2020)	Combining e-Participation with Augmented and Virtual Reality: Insights from a Design Science Research Project	ICIS
21	Blaschke et al. (2017)	Design principles for business-model-based management methods—a service-dominant logic perspective	DESRIST
22	Augenstein et al. (2018)	Development of a data-driven business model transformation tool	DESRIST
23	Babian et al. (2010)	Usability through system-user collaboration: Deriving design principles for greater ERP usability	DESRIST
24	Gnewuch et al. (2018)	Designing conversational agents for energy feedback	DESRIST
25	Rietz & Schneider (2020)	We see we disagree: Insights from Designing a Cooperative Requirements Prioritization System	ECIS
26	Horlach et al. (2019)	Agile portfolio management: Design goals and principles A	ECIS
27	Giesbrecht et al. (2014)	Learning with facilitation affordances: The case of citizen advice services	ECIS
28	Zierau et al. (2020)	Towards Developing Trust-Supporting Design Features for AI-Based Chatbots in Customer Service	ICIS
29	Augenstein & Maedche (2017)	Exploring Design Principles for Business Model Transformation Tools	ICIS
30	Vogel et al. (2019)	Leveraging the internal crowd for continuous requirements engineering – Lessons learned from a design science research project	ECIS
31	Rietz & Maedche (2020)	Towards the Design of an Interactive Machine Learning System for Qualitative Coding	ICIS
32	Wiethof et al. (2020)	Design and Evaluation of a Collaborative Writing Process with Gamification Elements	ECIS
33	Nadj et al (2016)	A situation awareness driven design for predictive maintenance systems: The case of oil and gas pipeline operations	ECIS
34	Szopinski (2020)	Exploring design principles for stimuli in business model development tools	ICIS
35	Vössing et al. (2019)	Evidence from an automated production line	ECIS

Table B2. Subsample of Selected Conference Papers (n=40)

Appendix C. Validation

For validating the Principle Constructor, we matched the principles of form and function for visual inquiry tools (Avdiji et al., 2020) with our tool.

Visual inquiry tools (design theory)		Implementation in our artifact (Principle Constructor)
Conceptual model	Frame	Our tool has mutually exclusive and collective exhaustive components guiding researchers through the main aspects of the design principle production.
	Rigor and relevance	Our tool builds on available methodological knowledge (justificatory knowledge) as well as practices in producing and communicating design principles extracted from IS literature. Also, the relevance of the components is evaluated by researchers.
	Parsimony	Our tool consists of 16 components. In comparison to other canvas-based approaches, our tool has more components but we are confident that this is important because evaluation participants asked for more guidance on what should be reflected. However, the categorization into four areas and the color coding are intended to make the tool still easy to use.
Shared visualization	Functionality	Our tool's components are represented as empty problem spaces to support the directions for use.
	Arrangement	Our tool draws on logical flow, for instance, in the solution area, from abstract knowledge at the top to specific knowledge. The areas themselves are summaries of interrelated components.
	Facilitation	Our tool has small icons for each area to graphically support the use.
Directions for use	Ideation	Our tool provides four different production patterns (i.e., typical configurations) and a catalog of guiding questions to support researchers during the application. Ideas, problems, prototypes, and (interim) results can be stored, presented (e.g., via sticky notes within the tool), and jointly refined across several iterations.
	Prototyping	
	Presentation	

Figure C1. Matching Design Theory for Visual Inquiry Tools with the Principle Constructor

Appendix D. Evaluation

Results of the evaluation episode for analyzing the understandability and relevance of the Principle Constructor during the first iteration of the design and development phase.

Area	Potential component	Average rating
Foundation	Empirical foundation (e.g., experts, documents, cases)	4.50
	Foundation: Scientific literature	4.33
	Theoretical foundation (e.g., kernel theory)	3.33
Problem space	Specification of class of problems	4.00
	Formulation of specific problem (e.g., use case)	4.00
	Formulation of corresponding research question(s)	4.00
	Meta requirement	4.33
	Design requirement	3.67
	Overall solution objectives	3.83
	Key issues and challenges (specific)	3.83
Solution space	Specification of class of solutions	3.33
	Design goals	4.33
	Design principles	4.83
	Formulation template for design principles	4.50
	Design feature	3.60
	Artefact / instantiation	3.17
Research paradigm and methods	Underlying paradigm (DSR, ADR, ...)	4.50
	Design method (e.g., Grounded Theory)	4.33
	Evaluation method (e.g., case study, field study)	4.50
Additional aspects	Collaboration (i.e., design team, developer)	4.00

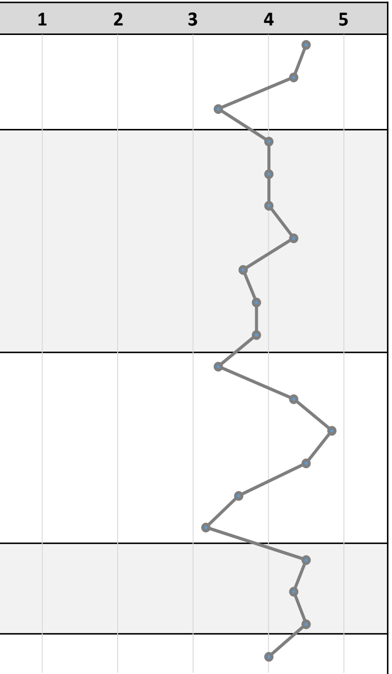

Figure D1. Relevance Ratings

The following figure summarizes exemplary statements from the participants. We took notes/memos during the workshop session and paraphrased statements concerning the Principle Constructor's usefulness and applicability.

Participant	Memo (paraphrased, recalled from discussion)
1	Will be very good for the initial phase [of starting with a design principle project].
2	[The tool] is very interesting and helpful.
3	I am a big fan of building block-based approaches that show components of design principles, avenues for the development, methods to be considered, as well as general aspects to be considered. The main user group is probably researchers.
4	Will simply the work [in design principle projects]. For both researchers and practitioners. The charm of clarity. Canvas is modern.
5	Super helpful. The analysis phase – how to evaluate the results [design principles] and how to transform them.
6	The space of how to build [design principles] is often larger than the way of how one develops design principles. This helps; gives inspiration. New ideas concerning what can be done.
7	Clarity. The complexity of building [design principles] becomes clearer.
8	How to operationalize design principles? Design features.
9	Probably especially helpful for the brainstorming phase.
10	I like to have concrete steps on how to proceed.

Table D1. Example Statements

Information Systems & Computing Academic Professionals

Education Special Interest Group

STATEMENT OF PEER REVIEW INTEGRITY

All papers published in the ***Journal of Information Systems Education*** have undergone rigorous peer review. This includes an initial editor screening and double-blind refereeing by three or more expert referees.

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