Sharing Design Knowledge Through Codification in Interdisciplinary DSR Collaborations

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Abstract

The goals of design science research (DSR) projects are to generate novel and useful artifacts and to produce rigorous and generalizable design knowledge. Often, DSR projects are conducted in collaborative, interdisciplinary project teams. Different disciplinary approaches to codifying design knowledge result in challenging project interactions. To study this situation, we analyze design knowledge codification in interdisciplinary teams over time. We gain insights from a survey of recent DSR papers that have been published in the AIS Senior Scholars' Basket. We then present a detailed case study of a longitudinal project that brought to light issues of sharing design knowledge across disciplinary borders. Drawing from the survey and case study, we provide actionable guidance on how to effectively codify and share design knowledge to support researchers and practitioners to build useful artifacts and to make interdisciplinary design knowledge contributions reusable and applicable.

Keywords: Design science research, design knowledge, codification, collaboration, interdisciplinary teams.

1. Introduction

Design science research (DSR) offers an important paradigm for conducting applicable and rigorous research about real-world design problems. DSR aims to generate prescriptive knowledge about the design of information systems (IS) artifacts (Hevner et al., 2004; Peffers et al., 2007), oftentimes generated in interdisciplinary project settings involving multiple application fields. In general, the "goal of DSR is to generate knowledge on how to effectively build innovative solutions to solve important problems effectively" (vom Brocke et al., 2020, p. 5). Thus, DSR projects make two key contributions. First, they expand the solution space of suitable solutions to design novel and complex IT artifacts. Second, they generate valuable design knowledge through designing artifacts for oftentimes complex and interdisciplinary problems. Design knowledge is a special form of knowledge, namely knowledge to design a system including models, methods, and constructs (Gregor & Hevner, 2013).

IS is an interdisciplinary discipline, which also affects the project constellation of DSR projects. DSR projects often connect researchers from different disciplines such as law, psychology, and education (King et al., 2010; Rhoten & Parker, 2004). Interdisciplinary project teams face additional challenges during the design process due to different views and common ground (Ancori et al., 2000). Typically, in designing artifacts, the projects make complex design knowledge tangible through codification – the detailed manner in which knowledge is coded, or represented, formally in that discipline. An important reason that makes design knowledge difficult to share and accumulate is the fact that design knowledge has certain characteristics and abstraction levels that are specific to the codified form for a research field. Numerous scholars, such as vom Brocke et al. (2020) and Rai (2017), identify the need to understand how DSR projects accumulate and codify design knowledge (Chandra Kruse & Nickerson, 2018).

IS literature emphasizes that codification supports expertise coordination by externalizing knowledge by making it more explicit and accessible (Kotlarsky et al., 2014). If we assess design knowledge as a crucial aspect in interdisciplinary DSR projects to get a shared understanding, we need an understanding of how the characteristics of codified design knowledge evolve over time. Thus, we inductively analyze a revelatory case of a longitudinal interdisciplinary DSR project

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over four years. We investigate how interdisciplinary DSR projects codify generated design knowledge and draw conclusions on how to codify design knowledge by answering the following research question (RQ):

RQ: How is design knowledge codified in interdisciplinary DSR projects to communicate among different disciplinary stakeholders?

To answer our RQ, we outline in a first step the theory background, focusing on knowledge codification in DSR projects and its roots. On this basis, we provide details of our multi-methodological approach and analytical framework to analyze design knowledge codification in interdisciplinary projects. We analyze extant DSR literature and a revelatory DSR case study to reveal codification practices for interdisciplinary DSR projects and to provide actionable guidance for researchers and practitioners in interdisciplinary design projects.

2. Design Knowledge Codification in Interdisciplinary DSR Projects

DSR is an established and widely used research method in the field of IS research for constructing artifacts (Gregor & Hevner, 2013) and is structured through process methods (Hevner, 2007; Peffers et al., 2007) to communicate the practice-oriented development of artifacts into IS research. DSR projects develop design knowledge through building, testing, and extending artifacts such as systems and theory across different projects and publications (Gregor & Hevner, 2013). The accumulation and codification of knowledge is a foundation for theories and enables both scientific research and professional practice (Gregor, 2006). Gregor et al. (2007) remark on the meaning of how design knowledge is expressed as a theory to make design science formalizable. The codification of knowledge enables the transfer of information from the human mind into a representational form. During this process, knowledge develops into a tangible structure, which uses codes and models translating into procedures, guidelines or documentations (Whitaker et al., 2010). Codification of knowledge enables knowledge to be passed on independently of the knower without personal exchange about the knowledge (Daft & Huber, 1986).

Creating and using knowledge has become one of the most important human characteristics, especially related to the valuable process of sharing it with other individuals (Nonaka & Takeuchi, 1995). For this purpose, codification of knowledge is an important process and learning mechanism (Ancori et al., 2000; Cowan & Foray, 1997; Kogut & Zander, 1992), especially when being confronted with diverse teams such as in interdisciplinary constellations. Designing (novel) artifacts and codifying emerging design knowledge is an important component of DSR. We define design knowledge codification as a process of conversion of design knowledge into messages that can be processed as transmittable information, i.e., sets of identifiable rules and relationships (Cohendet & Meyer-Krahmer, 2001).

In IS research, there has long been an interest in analyzing design knowledge, understanding its components, and supporting its accumulation and codification. In the early days of DSR, Walls et al. (1992) set the goals of a design theory in the description of both the properties of the artifact and the methods of construction to create the artifact. “Since design is both a noun and a verb, design is both a product and a process” (Walls et al., 1992, p. 42). In IS research, for example, Chandra Kruse and Nickerson (2018) have analyzed the essence of design in depth and evaluated nine design elements that facilitate design knowledge accumulation. vom Brocke et al. (2020) propose a model that puts design knowledge into the context of problem space and solution space. Thus, the authors provide a framework on how to position design knowledge contributions as accumulated in knowledge bases over time.

However, more and more interdisciplinary DSR projects are emerging that collaboratively develop artifacts. Brewer (1999) defines interdisciplinary as participation by diverse individuals. We already know from the literature on collaboration among interdisciplinary teams that new challenges arise in this regard. Morse et al. (2007), for example, identify the preference for traditional disciplinary work as one barrier in interdisciplinary team projects. Team members stay within their own disciplines and are only slightly open to new views, making it difficult to share and achieve a common goal. At the same time, the members often lack experience in working in interdisciplinary team constellations.

3. Research Method

We use a multi-method approach to analyze the design knowledge codification expression in interdisciplinary DSR projects. Our goal is to provide a comprehensive overview on how design knowledge codification changes and which properties of design knowledge predominate in each phase. We first conduct a systematic literature review of interdisciplinary DSR literature and then use the findings to analyze a specific longitudinal DSR project. Data from the project were collected between September 2017 and January 2021. Two of the co-authors had entered the project to investigate how the interdisciplinary project develops and shares design knowledge. They attended

team meetings, collected all project materials, and analyzed all codifications that supported messaging among team members. We performed qualitative coding to analyze the collected data using the following analytical framework.

3.1. Analytical Framework

We use a theoretical frame to analyze how the papers and our accompanied DSR project codify design knowledge in their projects. The coding frame is based on the design knowledge typology developed by Dickhaut et al. (2022a; Dickhaut et al., 2022b) which describes how design knowledge can be represented. We use the analytical framework to draw insights from the literature and inductively from the analyzed DSR project. In the following, we provide a short overview of our coding frame.

The generation of design knowledge takes place in a variety of ways, which is an important characteristic to understand its nature. It may emerge through:

- *Principles of form and function* (Gregor, 2006): design of artifacts generally and provide instructions on how to design those elements;
- *Instantiated implementation* (Gregor, 2006): developing programs or high-fidelity systems;
- *Prototypical design* (Lim et al., 2008): mainly developed for evaluation or demonstration such as mock-ups;
- *Development of a method* (Peffers et al., 2007): provide step-by-step instructions and provide users concrete directions to do something;
- *Developing models* (Li et al., 2019; Recker et al., 2021): formal artifact output to understand or explain occurrences.

The design knowledge derivation can be inductive, deductive or abductive:

- *Inductive:* based on theory;
- *Deductive:* based on empirical insights;
- *Abductive:* based on invocation of hypothesis.

To identify the aim of the design, we refer to Gregor (2006)'s notion of theory in IS and break down the design knowledge aim into the four characteristics analysis, explanation, prediction, and design and action:

- *Analyzing:* observing and analyzing a fact or an artifact to derive insights;
- *Explanation:* explaining causal relationships;
- *Prediction:* what will happen in future if certain conditions are met (Gregor & Jones, 2007);
- *Design and action:* designing an artifact (Gregor & Jones, 2007).

Our next coding focus is related to the level of abstraction. Thus, knowledge may be:

- *Context specific*: knowledge is less abstracted and applied in one case (Nonaka & Toyama, 2003).
- *Generally applicable*: knowledge is abstract and applicable in many cases.

To go more in detail, we focus on the knowledge expression level. We distinguish tacit, explicitly articulated, and explicitly codified design knowledge (Nonaka & Toyama, 2003):

- *Tacit knowledge:* is not represented or hardly represented what makes knowledge hard to grasp;
- *Explicitly articulated:* Auditory transmission of knowledge without writing it down;
- *Explicitly codified:* Structured text-based codification approaches.

Our last coding frame focuses on the main formulation and distinguishes descriptive and prescriptive design knowledge which is often used as a key indicator to analyze the knowledge reuse potential (Im & Hars, 1998; Schoormann et al.).

- *Descriptive*: describing knowledge;
- *Prescriptive:* providing guidance on how to do something.

3.2. Review of Extant Literature

To inform our interdisciplinary DSR case study, we analyze how interdisciplinary DSR papers develop and codify design knowledge. We conducted a systematic literature analysis according to vom Brocke et al. (2020) and Webster and Watson (2002) to identify the literature foundation of our paper. The goal of our systematic literature review is to identify papers that conduct DSR studies and are published in the AIS Senior Scholars' Basket (Association for Information Systems, 2011). We focus on journal DSR papers because most conference papers examine a small part of larger design science projects. In addition, we see the highest potential to learn how to codify design knowledge in a useful way from published journal papers. Reasons such as long and challenging review iterations force the author team to carefully make their acquired design knowledge available to reviewers and the readership.

To cover a broad set of publications, we use the keyword phrase "design science" in the databases. Table 1 provides an overview of the results. The initial number of 621 papers was reduced by reading the

papers' title, abstracts, and keywords. We reduced the literature by eliminating papers that are out of our scope such as papers that dealt with design science research from a conceptual or methodological viewpoint or did not involve interdisciplinary design projects. This resulted in a selection of 74 papers that are relevant for our following analysis (see Table 1).

Table 1. Overview of Literature Analysis

Outlets	Total Hits	Relevant Hits
MISQ	121	14
JMIS	85	18
JAIS	114	17
ISR	50	5
EJIS	115	14
ISJ	60	3
JSIS	24	2
JIT	52	1
Sum	**621**	**74**

Our literature analysis indicates that there is a wide range of DSR papers that vary in interdisciplinary composition. The disciplines range from healthcare (see, for example, Valecha et al. (2021)), law and security (see, for example, Oetzel and Spiekermann (2014)), to education (see for example, Nguyen et al. (2020)). Beyond that, it was also striking from the review that many DSR projects focused on interdisciplinary problem spaces but without being interdisciplinary, e.g., developing systems for the medical domain without partnering in interdisciplinary project settings (see, for example, Valecha et al. (2019) or Zhu et al. (2020)).

From the included papers, we identify that most of the included papers in the analysis develop prototypes and instantiations during their DSR projects. However, prototypes are not only developed at the end of the project but also earlier to weigh design solutions and evaluate them with other prototypes. It suggests that prototyping is a tool to achieve common ground in project teams. This can also be seen in the aim of the projects, as most projects pursue the goal of "design and action" and aim to solve a concrete problem through design. The problem to be solved usually involves interdisciplinary problems such as, the development of culturally adaptable interfaces (Reinecke & Bernstein, 2013) or the approach to improve security awareness through gamified learning (Dincelli & Chengalur-Smith, 2020).

On the way to the design solution (to develop process knowledge), the projects usually derive requirements in the form of models and use them for the design. The requirements describe the problem space in which the project team operates and delimit it to identify solutions. The derivation of design knowledge usually takes place either deductively (26 papers) or inductively (32 papers). Only 15 papers utilize an abductive approach. This can also be seen in the more detailed analysis, for example, most interdisciplinary DSR papers build on certain theories. For example, D'Aubeterre et al. (2008) use the situational awareness theory to close the gap between systems development and systems security.

If we now take a closer look at which design knowledge properties codify the projects, we can see a shift in focus. Most of the projects start by first defining the problem space and codifying the problem design knowledge. In the codification of design knowledge, the DSR papers in our analysis tend to follow a structured text-based approach (57 papers), for instance, by drawing on the notion of design principles (Chandra Kruse et al., 2022) or design theories (Gregor & Jones, 2007) or visualization (37 papers) through graphics and screenshots of the developed artifacts. Some of the papers also combine both. In conclusion, we find that design knowledge is mostly codified in a more descriptive way (52 papers) and fewer papers provide prescriptive guidance (26 papers). Although a set of papers presented multiple design cycles, rich insights into the role of design knowledge codification over time in these interdisciplinary projects are still missing. Thus, we present in the next section findings from an interdisciplinary research project to contrast the findings from prior literature.

4. Analyzing Design Knowledge Codification in an Interdisciplinary DSR Project

We draw on a revelatory case study approach to analyze how interdisciplinary DSR projects codify design knowledge. Referring to Yin (2018), our case offers the opportunity to observe and analyze a phenomenon previously inaccessible to social science inquiry. We accompanied a longitudinal DSR project that developed a voice-based law assistant. The research project was a nearly four-year project funded by the government and took place in Germany. The case gave us the opportunity to gain insights into collaboration and the importance of design knowledge codification in interdisciplinary teams, namely together with legal experts. We selected the DSR project because the case of a law assistant is timely and solves real-world problems and is a unique opportunity to analyze conflicting requirements (from law and IS) on the system to see how a solution is found together.

As stated in the previous paragraph, different disciplines are included. The core research team consisted of two disciplines: law and information systems (IS). Over time, computer science experts, education experts and the administration of the university were involved. Since intelligent agents such as Amazon Alexa and Google Home often led to legal problems, the project goal was to find a legal design solution for such systems (see Table 2).

In interdisciplinary design science projects, the codification of design knowledge becomes important to communicate and get a shared understanding. We traced changes throughout the DSR project by analyzing key steps and derived phases that switch the properties of codified design knowledge. In our case study, we identified four phases that define the longitudinal progress of the project as shown in Table 3. In the following, we apply the analytical framework to study codification to support interdisciplinary collaboration in the project.

Table 2. Interdisciplinary DSR Project

	Legal DSR Project
Problem Space	Developing an intelligent voice assistant that meets legal requirements and user requirements
Design Solution	Intelligent voice assistant
Codified Design Knowledge	Requirements patterns; design patterns; instantiated conversational assistant
Involved Disciplines	Legal experts; information systems; computer science; education
Evaluation	Experimental user study; legal simulation study
Project duration	4 years
Method approach	DSR

4.1. Phase 1: Requirement Development

The accompanied project started with several workshops in which the core team consisting of researchers from law and information systems exchanged ideas about the project framework and the core objective. There was a 20-page proposal at this point describing the project and outlining rough work packages as approved by the funding agency. The output of the project and how exactly the solution is achieved is mostly outlined in a way that provides room for the creativity of the project team. Therefore, the project team was free in their design of the next steps.

For the first milestone, the researchers decided to derive requirements from both disciplines to identify possible design solutions. While requirements engineering is a familiar tool for IS, it was new to the legal researchers. The IS requirements were derived from literature and practice, the requirements of the legal experts are based on legal texts and also differ at the content level. If we apply our theoretical lens of the design knowledge typology, differences can be identified. The requirements of the legal experts are significantly longer and more extensive but remain much more open in their level of abstraction and degree of solution. For example, one requirement was: *"It must be technically ensured that the conversational agent does not obtain consent for offers of information society services made directly to the person from persons who have not yet reached the age of sixteen."* While one exemplary requirement from IS was: *"The conversational agent's service should improve over the duration of use."* The requirements focus primarily on the problem space and specify what the goal state should be. However, the output is not yet specified. Therefore, the design knowledge was primarily still tacit and is externalized for the first time. In order to achieve an equal representation but also abstraction level and to make the types of requirements comparable, the research team decided to use a common template for the representation of the individual requirements. This structuring template provided essential support to externalize and codify the requirements as largely textual statements.

4.2. Phase 2: External Project Presentation

After the project started, we observed how the project team faced the challenge of presenting the project goal externally at a very early stage, when nothing presentable had been developed yet. In our specific case, the project needed to communicate to a committee of experts in the field of education and university administrators, who decided to what extent the developed artifact is suitable for the use at the university.

In preparation for the presentation, the core project team met and brainstormed ideas. They decided that the presentation needed to include more than the conflicting requirements of both disciplines. The university should see how the developed artifact can be used in teaching. Therefore, the project team decided to define use cases and scenarios.

While the previous knowledge codification of requirements was primarily related to the problem space, the focus has now moved strongly in the direction of the solution space (see Figure 1). If we apply the lens of knowledge representation from our

coding frame, we see that the codification is no longer purely text-based, rather design knowledge is being made available through visualizations and graphics, e.g., through low- and high-fidelity models. Ideas and possible solutions were deductively derived and demonstrate how an instantiated implementation could look like, for instance, in the present case through drawing upon service experience literature.

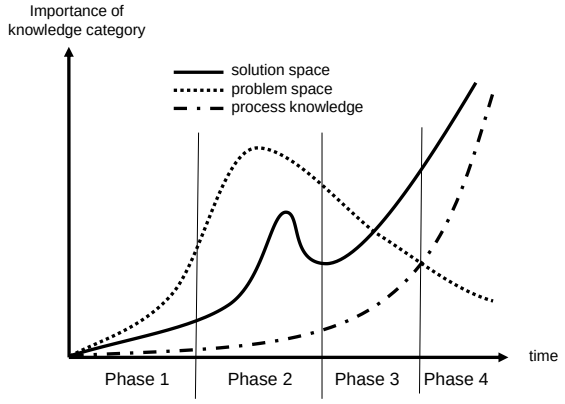

Figure 1. The Evolution of Design Knowledge over Time

The shift away from something abstract to concrete application scenarios narrowed the problem focus and emphasized the solution knowledge without taking into account how the solution can be achieved, thus highlighting the role of process knowledge in interdisciplinary design teams.

4.3. Phase 3: Combination of Divergent Requirements

In the third phase, the requirements that were elicited and put into a common form in the first phase represented the starting point for the further planning of the design. The overall goal of the project team in this phase was to utilize the requirements to find design solutions based on them. For this purpose, two project meetings were held, in which little design knowledge is codified but many potential designs are discussed. The biggest point of conflict was finding a joint solution that takes data protection aspects into account from a legal perspective but from a service development perspective continuously improves the assistant and supports users in their everyday lives in such a way that they enjoy using it.

The requirements analysis resulted in 58 requirements from a service quality perspective and 85 requirements from a legal perspective, all on a rather fine granular level. The large number of requirements from different disciplines were difficult to reconcile and organize. To get an overview, the requirements were categorized per discipline and labeled with a category description. The project team used a spreadsheet in which all requirements were codified. The team used this table to evaluate the individual requirements step by step in terms of their importance and to identify conflicts.

Table 3. The Evolution of Design Knowledge in DSR Projects

	Phase 1: Requirement Development	Phase 2: External Project Presentation	Phase 3: Combining Requirements	Phase 4: Design and Development
Discipline	Legal experts; IS research team	Education experts; IS research team; legal experts	Legal experts; IS research team; computer science	Legal experts; IS research team
Knowledge Generation				
Occurrence	Principles of form and function; requirement patterns	Prototypical design Use cases; possible scenarios	Principles of form and function design patterns	Instantiated implementation
Derivation	Deductive from law; Inductive research	Deductive from literature	Inductive	Inductive
Aim	Analysis	Explanation	Design and action	Design and action
Knowledge Purpose				
Unit of Design	Problem space	Solution space	Solution space; problem space; process knowledge	Solution space
Abstraction	Context specific	Generally applicable	Context specific	Context specific
Knowledge Representation				
Expression	Tacit	Tacit	Codified through design patterns	Codified through implementation
Formulation	Prescriptive	Descriptive	Prescriptive	Descriptive

While the first two phases focused primarily on the problem space and then abstract solutions from the

solution space, the search is now on for concrete solutions. The knowledge was written down in structured tabular form and explicitly codified.

4.4. Phase 4: Design and Development

The design and development phase is usually the crucial phase in DSR projects, where the design knowledge generated so far has to be built into an instantiated implementation or prototype. This crucial step requires the previously developed design knowledge. As known from the literature, it is helpful if explicitly codified knowledge can be built upon. Tacit design knowledge that is difficult to grasp must now either be concretized or is lost in this process.

Here, the disciplinary differences between the two disciplines emerged again. The legal experts tend to codify in a text-based manner, while the IS experts work more visually (e.g., graphic models) and often think in terms of implemented artifacts, for instance, related to database models or user interfaces. To implement a compromise of both disciplinary codification preferences, the project team used prototyping. In this context, we observe that legal requirements often contain few concrete instructions. Since law is generally technology neutral and is defined in abstract terms in legal texts, it is difficult for legal experts to develop process knowledge without concrete instructions on how to do something.

5. Discussion

5.1. Recommendations for Interdisciplinary Design Knowledge Codification

Building upon the findings of our literature review and our analyzed case, we discuss our findings with respect to the debate of design knowledge codification, accumulation, and projectability (vom Brocke et al., 2020). First, with respect to the review of DSR papers that focused on interdisciplinary projects, we can reflect upon the broad basis of completed DSR projects with multiple design cycles that knowledge was oftentimes codified through (at least) prototypical instantiations. At this point, knowledge codification in an interdisciplinary DSR project is from an end perspective rather less abstract and focuses more on the tangible solution. We think that this more explicit codification helped to gain in these projects a better understanding for bridging the shared understanding of stakeholders when looking at the design path from the problem to the solution space. Thus, leading to our first recommendation

> **R1:** Codify design knowledge into prototypes in an early project phase to obtain a shared understanding of possible affordances that the design artifact might provide.

The typical goal of the interdisciplinary literature is "design and action". The papers aim to solve concrete, mostly interdisciplinary problems by inductively generating design knowledge. This is also reflected in the outcome of the papers, which are mostly prototypes or instantiated implementations. We see patterns here that lead us to conjecture that interdisciplinary collaboration with IS research and the application of DSR is more likely to lead to concrete design solutions. On the way to a common design solution, interdisciplinary projects face the challenge that each discipline uses its own codification representations. In our accompanied project, uniform templates helped in weighting the requirements. Resulting in our second recommendation:

> **R2:** Codify design knowledge in textual and visual structures through mutually agreeable interdisciplinary design templates.

Next, we contrast these published findings with case-based findings from a multi-year DSR project involving multiple, interdisciplinary stakeholder groups. When considering the longitudinal nature of design knowledge codification, we witnessed a constant change how design knowledge occurred in its codification throughout the project. Being more formal in the beginning by relying on requirements engineering, internal stakeholders without IT knowledge from the education discipline were required quickly to think in solutions that could be discussed in the project. When thinking about the problem space model from Maedche et al. (2019), we not only see stakeholders linked to the problem space but also to the solution space. Thus, low-fidelity prototypical solutions served as a bridge codification mechanism addressing the disciplinary gap between silos through virtualization (D'Adderio, 2001). Nonetheless, this process iteratively circled back and forth in agile way. We expect that this natural way of dealing with codification in a more agile project setting helped to develop creative solutions to the complex problem space and, thus, overcoming the usual creativity gap when codifying knowledge in innovation processes (García-Muiña et al., 2009). These aspects are leading to our third recommendation:

> **R3:** Quickly move from the problem space codification to the solution space codification and iteratively cycle back and forth in an agile manner.

By formalizing design knowledge into reusable design patterns, a common ground for instantiating IT artifacts for goal evaluation purposes was established. In this context, the origin and aim of the design changed through deriving findings that are fit for further projectability but also in terms of being mature enough for the research community. Further, learning processes in the project between disciplinary silos were driven through continuous codification of design knowledge while addressing the working conflicts between silos. In that sense, knowledge codification mobilizes cognitive efforts (Prencipe & Tell, 2001) and influence learning between stakeholders through implementation, replication and adaption of design knowledge (Zollo & Winter, 2002). Thus, codifying design knowledge in interdisciplinary teams contributed to consensus building (Munier & Rondé, 2001), for instance, related to prioritization of requirements when being confronted with different stakeholders (Tuunanen & Kuo, 2015). Consequently, costs in codifying design knowledge, for instance, through the effort put into journaling (Vom Brocke et al., 2021) or various types of tool support (Morana et al., 2018), are justified (Cohendet & Meyer-Krahmer, 2001). Coming to our last recommendation, we state:

R4: Codify and journal design knowledge regularly to influence learning and replication.

5.2. Limitations and Future Research

Our study has limitations and offers room for further research. In order to get a comprehensive perspective on the codification of design knowledge in interdisciplinary project teams, we deliberately chose not to analyze literature or practical projects in isolation but to do both. However, we analyzed only one practical project, which makes it difficult to derive generalizable findings. Therefore, future research should analyze a range of different interdisciplinary DSR projects to derive findings. An expansion of studies to different disciplines may find important codification needs to be reconciled.

In our study, we analyzed how design knowledge is codified and representations evolve over time. Future research should go more into detail and work out what effects codification has, and which different representations emerge. In particular, the reasons why teams choose codification can derive important insights for the DSR community. Previous research often deals with the accumulation of design knowledge, i.e., accumulation over project time (see, for example, Legner et al. (2020), Rothe et al. (2020), Tuunanen and Holmström (2021) and vom Brocke et al. (2020)), but not specifically with codification, i.e., externalization and transfer into a codified form and how this is represented. Also, the different types of codified design knowledge, such as design principles, design patterns, and technology rules should be analyzed in much more detail in interdisciplinary DSR teams.

Our literature review has been limited to IS literature only. However, other design-related disciplines such as human–computer interaction, computer science, and innovation can also provide insights into the codification of design knowledge in interdisciplinary projects. Here, a look into the literature can pay off to get best practices. The same would hold true for the analysis of practice projects that are typically documented on platforms such as GitHub, where for instance computer scientists but also legal experts worked in the recent past on systems like COVID tracing applications (Pandl et al., 2021).

The analyzed papers provide little information about the development of design knowledge over time, although some papers provide brief insights into multiple design cycles but with an emphasis on the final artifact. This may be due to the use of a paper structure for the DSR approaches and the fact that papers often provide little detail on challenges and problems in team collaborations.

In the DSR community, there is already a move towards the use of design journeys across the DSR project. Such tools provide researchers and practitioners with the opportunity to codify developed design knowledge. Above all, they support regular codification and give others the opportunity to reuse the knowledge (Morana et al., 2018; Vom Brocke et al., 2021). The analysis of design journeys could provide further exciting insights into the codification of design knowledge and reveal changes in the form of codification.

6. Conclusion

The goal of our study is to analyze how interdisciplinary DSR project teams codify design knowledge and the impact of codification on their collaboration. For this purpose, we created a coding frame based on the typology of design knowledge by Dickhaut et al. (2022a) and analyzed interdisciplinary DSR projects in a multi-method analysis. Our multi-method approach consists of the deductive analysis of existing interdisciplinary DSR literature and inductive analysis of a longitudinal DSR project, which we were able to analyze over four years of activities.

Our literature review indicates that interdisciplinary DSR projects focus mainly on problem space. Most of the papers in our analysis follow a design and action approach to solve interdisciplinary problems. On the way to finding a

solution, the projects use prototypes early on to create a common ground in interdisciplinary collaboration. In our practical DSR project, we were able to see how the shape of design knowledge changes over time through different types of codification. Initially, a lot of knowledge is generated in the problem space after which the solution space is stretched out and becomes more and more specified over time. Together, the analyses provide a grounding for our four actionable recommendations for the sharing of design knowledge in interdisciplinary DSR projects.

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