Journal of Innovation Management
JIM 7, 3 (2019) 96-122
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0006
SM: Feb/2019 AM: Apr/2019

The Use of Design Thinking in Transdisciplinary Research and Innovation Consortia: Challenges, Enablers and Benefits

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Abstract. The innovation management literature describes a competitive advantage when applying Design Thinking (DT) in corporate environments. In this paper we study the perceived challenges, enablers, and benefits for implementing DT in publicly funded transdisciplinary industry-academia research and innovation consortia (RIC). We facilitate and investigate five large RIC from the food and high-tech industry in Norway and Germany using an explorative qualitative action research design. Our research shows that the challenges of using DT in RIC are to some extent comparable to those for the corporate context. Additionally, we identify distinct challenges for RIC. Benefits from using DT in RIC are stronger user and innovation focus, better transdisciplinary collaboration, and triangulation of qualitative with scientific data. We suggest that complex RIC benefit from an intermediary (DT) role translating business needs into research questions, and research results into understandable and business-relevant information and innovation.

Keywords. Design Thinking; Transdisciplinary; Industry-Academia-Collaboration; Research and Innovation Consortia; Innovation; Implementation; Challenges; Enabler; Action Research.

Cite paper as: Gonera, A., Pabst, R., (2019). The Use of Design Thinking in Transdisciplinary Research and Innovation Consortia: Challenges, Enablers and Benefits, *Journal of Innovation Management*, www.open-jim.org, 7(3), 96-122.

1 Introduction

Increased competition and a faster innovation pace in a globalized environment motivate participation in research-based innovation collaborations between industry and academia to solve problems none of the stakeholders can solve alone (Sandberg, Pareto, & Arts, 2011). The business model of research organizations however requires public funding, which historically is based on academic excellence only. There is a major change happening: Pure knowledge creation is no longer the aim of many research projects. Funding calls increasingly address complex societal challenges that can only be solved by transdisciplinary teams and in collaboration between industry and academia (European Commission, 2018, Federal Ministry of Education and Research, 2012, UK Government, 2017, Popowitz & Dorgelo, 2018). The recently developed EU mission-based research and innovation strategy addresses global challenges fostering experimentation and citizen involvement (Mazzucato 2018). This is also reflected in several core dimensions of change on how to organize innovation as described by Leitner, Warnke & Rhomberg (2016). Among them is a changing perception of creativity, changing motivation for innovation, and a need for systemic sustainability innovation, which will all strongly affect the way we execute research and innovation projects in the future. These developments seem to legitimize the use of Design Thinking (DT) in the context of publicly funded collaborative research. DT is a human-centered approach to problem-solving, creativity and innovation. DT is also a management concept of innovation that gained massive attention in the corporate world in the recent years and is often referred to as providing a competitive advantage (Liedtka, Salzman, & Azer, 2017, Brown, 2009, Brown & Katz, 2011, Rauth, Carlgren & Elmquist, 2015, Carlgren, Elmquist & Rauth, 2014).

Successful research projects must deliver on social, environmental and economic sustainability through innovation, collaboration, and solving wicked problems. This requires impact-focus and innovation management thinking from scientists and is challenging, as many scientists work to “understand” and not to “create”. In the context of RIC, facilitation of transdisciplinarity is needed in order to achieve a working mode where knowing and understanding each other and collaborating to extract the best from every discipline for achieving results beyond what one discipline could achieve alone (Thompson, Owen, Lindsay, Leonard, & Cronin, 2017). Transdisciplinarity in the setting of RIC can be characterized by different features according to Zscheischler, Rogga, & Busse (2017): collaborative problem framing and co-designing the research process, integrating knowledge form different disciplines, and science-practice collaboration.

We observe a mismatch between external funding and industry requirements and the scientists’ capability to lead and work in transdisciplinary impact-oriented projects. DT with its focus on user needs, co-creative problem-solving, and innovation outcome could help to bridge that gap when introduced in a way that accounts for both culture-, sector-, topic-, and team-specific factors in the socio-technical system of a RIC (Liedtka et al., 2017). DT has not been widely used in publicly funded research and innovation consortia, and there is a lack of understanding which challenges and benefits its use implies. The aim of this study is two-fold: Describe the facilitated introduction and continuous use of DT in RIC and study the perceived challenges, enablers, and benefits of implementing and using DT in RIC. In our action research-based case study, we selected five large RIC from the food and high-tech industry in Norway and Germany where DT was introduced and applied continuously.

2 Theoretical Background

2.1 Design Thinking

DT in an innovation management context can be described as a human-centered approach to problem-solving, creativity and innovation combining what is technologically feasible, with what is desirable and economically viable (Brown, 2008, Brown & Katz, 2011, Verganti, 2008, Beckman & Barry, 2007, Liedtka, 2015, Carlgren, Rauth & Elmquist, 2016b). DT is a meta-disciplinary methodology where pre-established rationales of one discipline are replaced with a mindset that helps to develop a common basis of knowledge and agreement between disciplines (Lindberg et al., 2010). The benefit of DT is still difficult to proof and measure. One of the few measurable successes of design-centric companies that are part of the design value index is that they outperform their peers from the S&P500 by over 200% (Rae, 2016).

The core elements of DT are empathy and people focus, problem framing, visualization, experimentation, and diversity (Carlgren et al., 2016b). They are often paraphrased or visualized by an array of diverging and converging processes of need finding, idea generation, and testing (Liedtka, 2015) in contrast to more traditional product-centric stage gate and linear innovation processes (Cooper, 1990). Different models of operation with a more or less rigid set of tools and methods exist based on their origin and primary use at e.g. IDEO, Hasso Plattner Institute, Darden School of Business, or the British Design Council (Tschimmel, 2012, Carlgren et al. 2016b). The Double Diamond model from the British Design Council is divided in four distinct phases (see Figure 2): The diverging *Discover* phase - gathering new insight by looking at the world from different perspectives. The converging *Define* phase - making sense of the information from the first phase and deciding which opportunity matters most. The diverging *Develop* phase - repeated cycles of creation and testing of concepts and prototypes leading to constant improvement of ideas. The converging *Deliver* phase - validating and implementing the innovative solutions (products, services, technologies, designs, business models).

It should be noted, that DT is not only a toolset but also a mind-set and therefore not easy to implement in settings where linear thinking and hypothesis-based working are the dominant logic (Carlgren, Elmquist & Rauth, 2016; Liedtka et al., 2017). We planned and researched the use of DT in RIC according to the Double Diamond Model and its phases as our project facilitation framework and theoretical lens.

2.2 Design Thinking in the Corporate Context

Brown and Katz (2011) encourage the use of DT and the designer's creative problem-solving skills by non-designers into the broader organization. As stated above, adaptation and use of DT is however challenging when coming from a different school of thought where a technology or product is often developed and put onto the market rather than starting with a user need. While designers are comfortable with insecurity and ambiguity, managers and scientists are usually risk averse and afraid of failure.

Several academic studies describe theoretical reflections of conceptualizing DT (Johansson-Sköldberg, Woodilla & Çetinkaya, 2013, Kimbell, 2011), an empirical study by Carlgren et al. (2016) is deliberately distancing itself from that approach by focusing on the use, users, terminologies, and perception of DT in large corporate organizations. Carlgren's study leads to a better understanding of how and why DT is used and proposes a research agenda to better understand the value of using DT, to develop a common language when discussing DT, and to study DT as managerial practice. The authors call for more empirical studies on how DT is used and which value it creates depending on the context it is applied in as well as how DT skills are learned and taught in an organizational/project context.

Seven specific challenges unique for using DT are described by Carlgren, Elmquist & Rauth (2016a) based on empirical data from five large firms (see Figure 1). The challenges are linked to the inherent characteristics of the DT concept itself in relation to its core themes: user focus, framing, experimentation, visualization and diversity (Carlgren et al., 2016b) and distinct from established barriers to innovation. A more structured approach to DT is needed when practicing DT with non-designers, relating to competency development, establishing structures and routines and the facilitation of DT (Liedtka et al., 2017). The study of Rauth et al. (2015) on legitimizing DT in large organizations identifies five ways to create or sustain support for DT (see Figure 1). The challenges to overcome uncertainty around the DT concept that encourages failure and exploration outside the comfort zone were especially large in organizations with traditional R&D structures. This could also be the case in RIC based on their R&D centric nature.

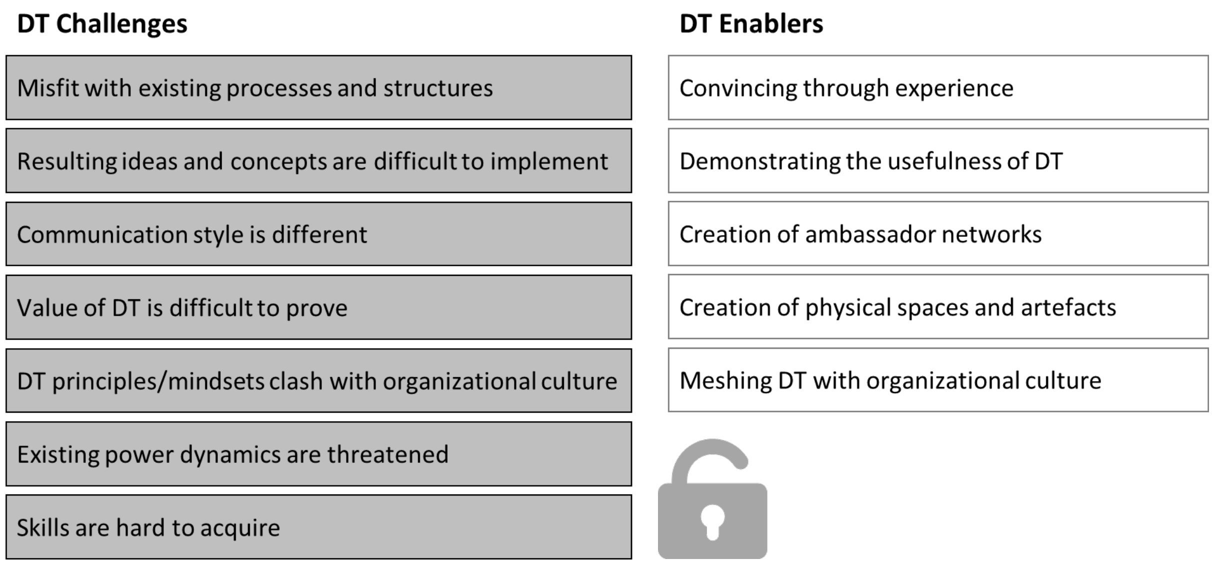

Fig. 1. Challenges and Enablers for using DT in Corporate Context according to (Carlgren et al., 2016a, Rauth et al., 2015, Seidel & Fixson, 2013)

A recent study of 50 industry projects from Liedtka (2018b) describes DT as a paradigm that enables people's full creative energy, commitment, and an improved innovation process. DT

ISSN 2183-0606
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creates a natural flow from early insights to user experiences to the transformation of these insights into ideas and actionable solutions. The DT process overcomes human biases and is able to provide immersion, helps sense-making, builds alignment, and fosters articulation: *"What makes DT a social technology is its ability to counteract the biases of innovators and change the way they engage in innovation processes".* Another study (Liedtka, 2018a) of 22 companies, NGOs, government association (no industry-academia collaboration projects) explores the impact of DT in action and describes the observed practices of deep understanding of user needs, heterogeneity of teams, dialogue-based conversations, multiple solution outcome, creation of a structured and facilitated process. Those practices have shown to lead to improved quality of choices, reduce risk and cost failure, enhance likelihood of successful implementation, increase adaptability, and contribute to capability building. These are practices and outcomes becoming increasingly important also for industry-academia collaborations.

Existing research on DT as method, mindset, and innovation enabler is limited to corporate environments and often restricted to a single company or comparison of a few companies (Carlgren et al., 2016a, Rauth et al., 2015, Wrigley, 2017, Liedtka, 2018b). This underpins a lack of understanding on how DT is practiced in organizations and how DT benefits innovation outcome. Based on literature search, we discovered an even larger research gap on understanding how DT is used in large multi-year science projects with interorganizational and transdisciplinary industry-academia collaboration such as RIC.

2.3 Industry-Academia Research and Innovation Consortia and Design Thinking

The main differences between corporate R&D and academic R&D is the focus on business productivity versus personal productivity and building customer value versus building reputation with peers (Simons, Gupta & Buchanan, 2011). Corporate R&D appears to have goals and motivations similar to DT (user desirability, technical feasibility, commercial viability) whereas academic R&D is more self-centered and focuses on academic merits and peer recognition. The authors suggest that some of the DT motivations and tools could apply to corporate R&D especially by working multidisciplinary, collaborating radically, incentivizing knowledge sharing and change. However, Simons et al. (2011) merely raise questions rather than providing answers on how this potential can be utilized. Due to the different nature of corporate and academic R&D challenges implementing DT into RIC are expected to be different and multifaceted and currently not understood.

RIC become increasingly complex and different communities of practice working to solve a large scientific or innovation challenge are needed. "*Conceptually, transdisciplinarity aims to foster meaningful knowledge co-production through integrative and participatory processes that bring together diverse actors, disciplines, and knowledge bases.*" (Thompson et al., 2017). This concept is not easy to implement as disciplinary success is often higher rewarded in academia and communication between disciplines can be a major challenge (Benard & de Cock-Buning, 2014, Basche et al., 2014). Designers can act as brokers through applying their user centric, socio-cultural and product semantic skills to the creation of new (product) meaning (Verganti 2003) and have the ability to successfully facilitate multi-stakeholder co-creation activities (Aguirre, Agudelo &

Romm, 2017). Alves, Marcques, Saur & Marques (2007) study multidisciplinary and multisectoral cooperation as catalysts for creativity and innovation without explicitly mentioning DT but describing some of the tools and methods. Their study provides a limited view on new product development and does not include long term collaboration projects or RIC. Interestingly, diversity from multidisciplinary and multisectoral collaboration is discussed exclusively as positive for innovation. Emerging management challenges are mentioned only very briefly and remain unspecific.

The expectation to collaborative R&D is moving more towards impact creation (Mazzucato, 2018). However, classical project management in an innovation context has its limitations in a sense that it tries to apply a rigid framework to an agile and unpredictable process (Mahmoud-Jouni, Midler & Silberzahn, 2016). The expected contributions of DT to project management in an innovation context for exploration, stakeholder involvement and strategizing on a theoretical level provide an interesting steppingstone for our work in RIC. Garousi, Petersen & Ozkan (2016) identified 10 challenge themes and 17 best practice themes in their review article on industry-academia collaborations. Most common best practices documented in different contexts are regular workshops and seminars, continuous learning from industry and academic sides, ensuring management engagement, the need for a champion, conducting research based on real-world problems, showing explicit benefits to the industry partner, and agility during the collaboration. Once more the described practices are coherent with a DT-mindset, but DT was not explicitly applied or mentioned. A recent action research study reveals a positive impact of co-production / co-creation activities (as in DT) to joint problem formulation, research methodology, capacity-building, communication, and project outcome in industry-academia collaborations (Sannö, Ericsen Öberg, Flores-Garcia, & Jackson, 2019), however, DT has not been mentioned specifically as facilitation tool.

Many of the studies mentioned above describe shorter activities compared to RIC projects with focus on an innovation solution or are even purely theoretical. Principles of co-creation, agility, transdisciplinarity, industry relevance, and innovation outcome are the focal point of several scholars. According to our literature search, DT has not been used extensively and consistently nor has it been studied in industry-academia collaboration such as RIC to increase transdisciplinary collaboration, user focus/relevance and innovation outcome. Thus, there is a research gap on both the use of DT in RIC and understanding the challenges and benefits this implies. The research question in this paper is: How can DT contribute to better collaboration across disciplines and between theory and practice in complex industry-academia RIC? The aim of this study is therefore two-fold: Firstly, we elucidate how we use DT in RIC to foster transdisciplinarity and innovativeness by describing and analyzing five large RIC (our cases). Secondly, we empirically study the perceived challenges, enablers, and benefits of implementing DT in RIC in the light of existing research. Focus of the research is on the use of DT as facilitation tool to improve transdisciplinary collaboration, user-focus, and innovation outcome in RICs.

3 Method

3.1 Research Context and Case Descriptions

We studied the use of DT in joint academia-industry research and innovation consortia (RIC) from a pre-project stage throughout the project's duration. We designed and selected the RICs based on the following common criteria in order to assure comparability across cases:

- they are publicly funded based on competitive research proposals, which means similar set-up and KPIs,
- the projects require a high degree of transdisciplinarity, which is challenging to realize in traditionally run RICs
- the DT methodology is new to the project teams, and thus allows us to study the implications of using DT in an exploratory action research setting,
- they have a Design Innovation Catalyst (Wrigley, 2017) also acting as the action researcher assuring robust implementation and execution of DT activities
- the project duration is between four to six years with minimum three years into the project allowing for rich and diverse activities and data collection throughout all phases of the DT process.

We studied three national and two international RIC from the food industry and high-tech industry in Norway and Germany, respectively. Table 1 shows an overview of the five cases in this study.

Table 1. Overview of Research and Innovation Consortia in the Study

Case	Funding	Participants	Description
Plant Protein	EUR 4 mill NRC BIONÆR	22 partners (13 research organizations, 9 food companies) from 5 European countries	Research Project: Develop knowledge platform for optimal production/utilization of Norwegian plant raw materials accelerating adaption and value creation from plant-based protein-rich resources to future food products.
Food Safety	EUR 9 mill EU H2020	32 partners (7 NGOs, 18 research organizations, 3 large enterprises, 4 SMEs) from 14 European countries	Research and Innovation Project: Reducing health burden from foodborne illnesses by changing consumers' behavior through effective and convenient tools and products, communication strategies, education and an inclusive food safety policy.

Case	Funding	Participants	Description
Food for Elderly	EUR 1.5 mill NRC IPN and industry funding	8 partners (4 food companies, 4 research organizations) from Norway	Innovation Project: New insight and knowledge related to elderly people as basis for the development of innovative products, services, and communication strategies that can motivate and facilitate healthier diet and healthy ageing.
Innofo3D	EUR 0.4 mill in a EUR 45 mill BMBF consortium	90 partners (27 research institutes, 47 SMEs, 16 large enterprises, 3 research networks) from Germany	Innovation Research Project: Applied innovation and communication tools, services, and scientific publications for the innovation consortium "3Dsensation" (transdicsiplinary human-machine-interaction innovation)
Camera Sensor	Subproject in EUR 45 mill BMBF consortium	5 partners (large enterprises, SMEs, research institutions)	Product Development Project in the field of human-machine-interaction for the development of a camera sensor

3.2 Design Thinking Approach and Activities in the RIC Cases

We can distinguish between description-driven, explanatory research and prescription-driven design sciences, with an added value, solution focus, and practical relevance of the latter within management research (Aken, 2004). This encouraged our approach of using DT in a field of otherwise explanatory research domains. Applying DT is learning in action (Liedtka, 2018). Based on the hands-on experiences of using this innovation method in five RIC perpetual new insights about the key enablers and challenges were generated.

Classical RIC operate according to a linear project model with a predefined set of activities, often in silos and with little iteration. The linear activities are reflected in a critical path schedule with milestones and deliverables adapted to the reporting requirements following an annual cycle. The DT approach with its iterative phases is new to RIC. Figure 2 describes the project phases of RIC overlaid with the Double Diamond DT phases. The iterative nature of the DT process is reflected by the circular arrows within and between the diverging and converging DT phases. As RIC depend on public funding, a pre-project application phase 12 to 18 months prior to project start is illustrated.

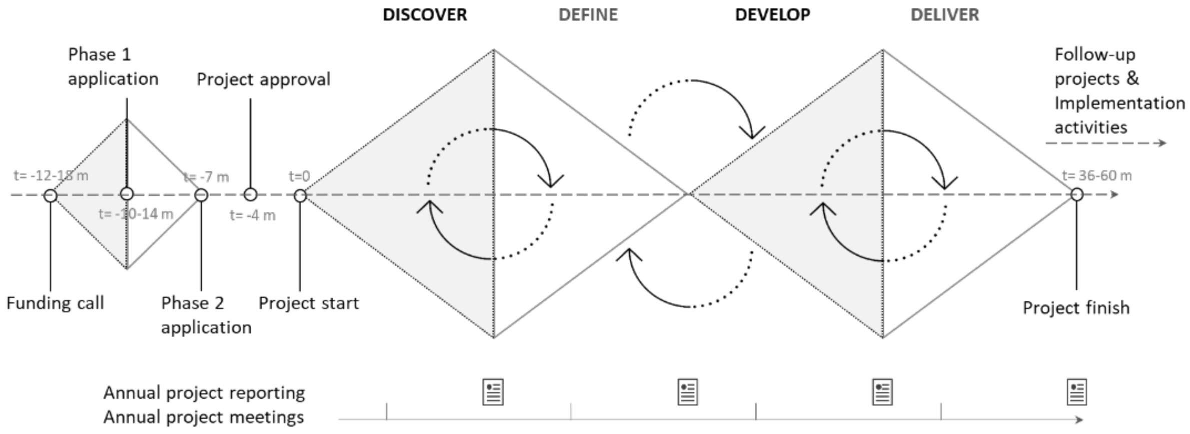

Fig. 2. A typical RIC timeline with project phases overlaid to Double Diamond and DT phases

In the various RIC we used DT as a novel approach to facilitate collaboration and innovation activities, take user-centric perspective, achieve transdisciplinarity, and translate insights into innovations as shown in Table 2.

Table 2. Overview of the use of Design Thinking in Research and Innovation Consortia

Case	**Aim of using DT**	**DT Methods used***
Plant Protein	Achieve transdisciplinarity, Develop innovation strategy, Translate insights into innovations, Work user centric	Future visions, user observation, user survey, prototyping, personas, visualization, co-creation workshops, teambuilding, field trips, iterative testing and validation
Food Safety	Achieve transdisciplinarity, Translate insights into innovations, Work user centric	User observation, user survey, user journey, pains and gains, reflexive DT workshops, opportunity area definition, brain storming, innovation workshops, product design projects, prototypes, visualization, testing and validation
Food for Elderly	Improve project collaboration, Translate insights into innovations, Work user centric	User observation, user survey, personas, pains and gains, user empathy, business ideas, storytelling, prototyping, testing and validation
Innofo3D	Develop innovation strategy, Facilitate transdisciplinary collaboration, Work user centric	Networking, games, roadmaps, personas, user observations, user survey, ideation workshops, storytelling, value proposition design, pitching, prototyping, user testing

Camera Sensor	Facilitate innovation, Facilitate transdisciplinary collaboration Develop new products	Stakeholder analysis, shared vision, persona, storytelling, user journey, value proposition design, pitching, prototyping, user testing

*only main examples, not exhaustive

We deliberately distance our research methodology from the "spectator - astronomer" or "stranger - visitor" paradigm where a researcher observes without intervening (Eikeland, 2006). Transformative knowledge creation can only arise in the context between researchers and practitioners (Bradbury-Huang, 2010) and not as simple observers or through interviews. The large gap between disciplines, and between research and practice in RICs calls for an intermediary role translating research results into understandable and business-relevant information, and business needs into research questions. This role can be described as *Translational Developer* (Norman, 2010) or more relevant for our research the *Design Innovation Catalyst* (Wrigley, 2017, Wrigley, 2016). Wrigley derives six important capabilities of the Design Innovation Catalyst from empirical case studies: designer knowledge and skills, business knowledge and understanding, cognitive abilities, customer and stakeholder centricity, personal qualities, and research knowledge and skills. In line with the DT approach, action research (Guertler, Sick & Kriz, 2019, Guertler, Kriz, McGregor, Bankins & Bucolo, 2017) and engaged scholarship (Van de Ven, 2007) comprise similar benefits of better collaboration, capability building, increased relevance of the research methodology. The research was therefore carried out as action research where the researchers acted as boundary subject, process leader, change agent, and innovation catalyst (Huzzard, Ahlberg & Ekman, 2010, Price, Wrigley & Matthews, 2018, Wrigley, 2016). Our primary purpose was not only understanding how to implement DT in RIC but actively effect the desired changes and empower stakeholders. Our action research and its central elements are designed to solve a research challenge (the RIC's thematic research focus) and thus has the ability to combine an academic knowledge gain with solving a practical problem and capability building (Guertler et al., 2017).

3.2 Data Collection and Analysis

As research on using DT in RIC is scarce, we applied an explorative qualitative research design. This study builds on a multiple case study (Yin, 2017, Eisenhardt, 1989) investigating five RIC from different industries and different countries.

The findings of this study rely on a three-year co-creational knowledge generation process. The data was collected in the period of 2015 to 2018 in the different phases of the case projects. The iterative DT activities and linked learning cycles took place in each of the five RIC and is based on a two-fold knowledge creation process due to the role as Design Innovation Catalyst and action researcher (see Figure 3). We organized and participated in events, workshops, project meetings, and conferences where we observed the behavior of project participants in each of the cases. During and after these events we took detailed field notes and photographic documentation. Additionally, we conducted semi-structured and informal interviews with representatives of our case organizations and took part in informal reflective conversations. Observations and interviews revolved around the use of DT in the RIC context, how it was perceived, what the benefits and challenges were and how the approach could be improved.

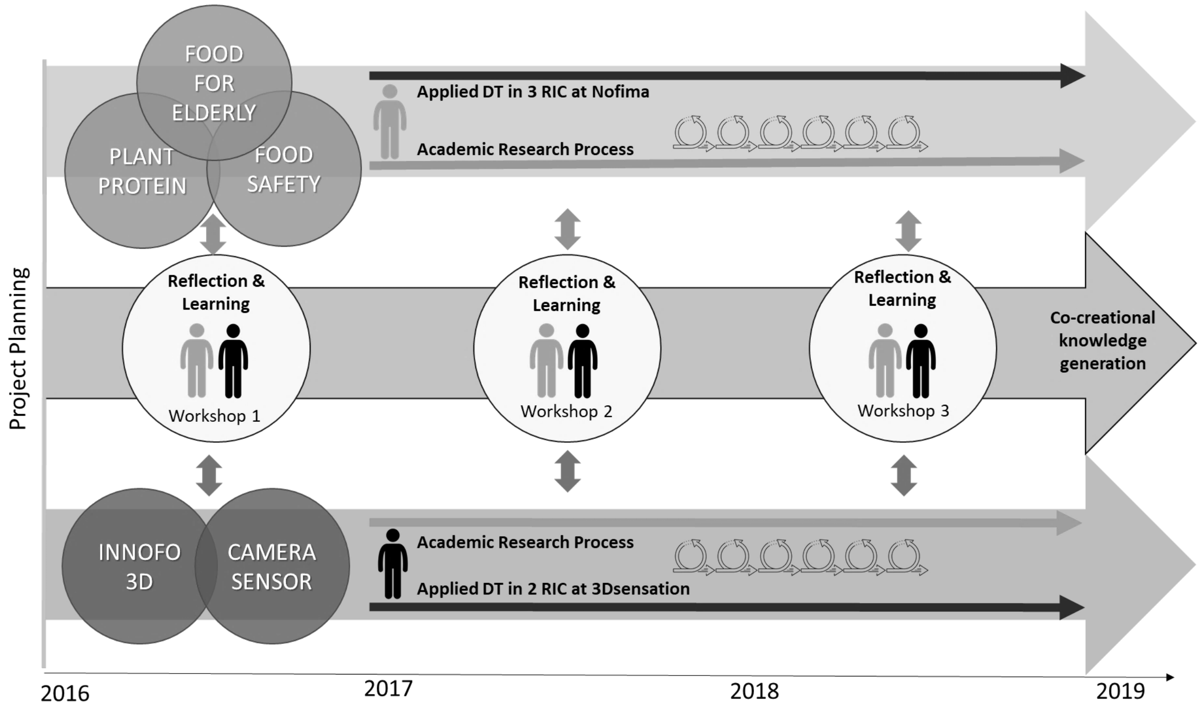

Fig. 3. Illustration of action research approach within and between five cases

We comprehensively collected secondary material describing the broader context of the cases (policy documents, company information, project descriptions, and results from other activities in the RIC). This allowed triangulation of the findings from our interviews and observations, strengthening the quality of our findings (Flick & Gibbs, 2007). Knowledge creation took place by practicing DT at different stages of the research and innovation projects and validating the gained insights. The researchers shared their insights, reflected their learnings, and designed upcoming DT and research activities in three annually held one-day face-to-face workshops and had shorter exchange meetings during the three-year data collection period.

For further exemplification of our advancement and explanation of how we gathered and analyzed the data within each RIC, Table 3 provides an overview of one RIC's project activities and events for the *Innofo3D* case, their link to the respective DT activities and the action research activities performed at each point in time. The iterative character of DT is reflected by a variation in DT process stages depending on the goals of the particular participants or stakeholder goals at the given project phase.

Table 3. Event specific Design Thinking and Research Activities at Innofo3D

N	Event Type and Characteristics	Date	Design Thinking Activities	Action Research Activities
1	2016 Annual consortium conference, 80 people of 90 member organizations participated	June 22-23, 2016	DISCOVER: Moderation of several project kick-off sessions: Introduction to DT methodology and benefits of applying it as an innovation process, moderation of network sessions aiming at building trust	5 Video interviews with RIC project owners about DT, in particular: user focus, empathy and challenges of the application of DT as a project-centered innovation method
2	Prototyping workshop, Consortium internal open 2nd call: "Idea-Invention-Innovation (I^3)" program, around 25 people from 17 different organizations attended	September 30, 2016	DEVELOP: Execution of a one-day prototyping DT workshop (Lego or role-play) including a testing phase, 90s elevator pitch explaining the concrete idea for a one-year side research and innovation project program	Analysis of feedback and evaluation forms of 25 participants about how they perceived the prototyping workshop (takeaways, ideas for improvement) An additional observer joined the workshop and filled out an empathy map to gain deeper insights of the workshop participants
3	Panel presentation and discussion	June 28, 2017	DISCOVER: User Journey of scientific research within an academic-industry innovation project aiming for building empathy	Field notes from discussion with RIC members as well as industry experts at the panel session and trade fair booths

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N	Event Type and Characteristics	Date	Design Thinking Activities	Action Research Activities
4	3 Business design workshops with one RIC, 3 to 7 persons of the different member organizations of one RIC participated	November until December 2017	DEFINE & DEVELOP: 3 one-day workshops for defining the Point of View (POV) while using the concept of personas as well as the generation of ideas for distinctive application areas and ideas concerning the business model	Analysis of the participants appreciation of mixing DT, e.g. business model canvas within a brainwriting session, validation of the approach via feedback and evaluation forms and informal discussions
5	2017 Annual consortium, conference, around 80 people of 90 member organizations participated	October 23-25, 2017	DELIVER: Execution of a "Human-Machine-Interaction Hackathon" Prototype validation, testing for hypothesis, concept testing (mockups), pitch of solutions	Follow-up of the winning approaches in forthcoming research and innovation projects funded by the consortia, gaining further insights from mentoring of teams that found each other at the hackathon
6	RICs project kick-offs and workshops	2017 until 2018	DISCOVER: Demand of RIC for more user insights, mapping possible alternatives for technologies, DT & google sprint related activities	Researcher moderated at least 5 meetings and workshops including questioning and feedback form evaluations, activities were initiated by the RIC

N	Event Type and Characteristics	Date	Design Thinking Activities	Action Research Activities
7	Consortium board meetings	2017 until 2018	DISCOVER & DEFINE moderation of 5 board meetings by applying DT methods including (presentation of user journeys of the RIC, post-it brainstorming, project mapping etc.)	Researcher focus was to gain insights from the stakeholder perspective of the consortia. The outcome of each session was documented by an assistant and analyzed by the researcher
8	2018 Annual consortium conference, 75 persons from 90 members participated and 60 external academia and industry expert joined for the open second- and third day	September 17-20, 2018	DISCOVER: this year's event included special sessions "spots on dialogue" focusing on the open exchange for collaborative research progress as well as building further trust among the partners of this consortia	Analysis of the feedback and evaluation forms, an additional observer joined the workshop and filled out an empathy map to gain deeper insight of the workshop participants

Analysis was carried out within cases and across cases according to Yin (2017). We chronologically documented all data linked to the respective activity and project phase of the individual cases. The material was sorted into clusters representing the respective DT activities, observations, and interview notes. The derived challenges and enablers for using DT were then clustered and further refined. A case summary of each case was written to complement the aggregated data and enable cross-case comparison. The analysis was iterative and emerging themes were compared with results from previous research on challenges, enablers and benefits of using DT in other contexts. Categories of analysis in our research where for example individual DT workshops, DT methodologies, workshop outputs, and stakeholder groups. Emerging themes and results were discussed between the researchers and third persons within RIC project teams and in three reflection & learning workshops across all cases. The generated knowledge was immediately applied in further project and research activities. One example of generated knowledge from our reflection & learning workshops is the learning that we need to focus thoroughly on DT capability building in order to successfully use the tools and change a researcher's mindset. This resulted in increased DT training and exposure to DT in the RIC in addition to the already planned activities. Another learning is that the term DT as such can create aversive reactions which made us focus on the actual workshop output and flow much more than the fact that we are doing DT.

4 Results and Discussion

As the use of DT in RIC has not been studied previously, we build our analysis on different streams of literature from management research, action research, and DT and combine it with our own research data to derive specific challenges, enablers and benefits of using DT in RIC. We deliberately do not include classical innovation barriers (Tushman & O'Reilly, 1996, Kanter, 2006, Tidd & Bessant, 2018, Bessant, Öberg & Trifilova, 2014) in our analysis as we want to focus on the DT specific elements.

4.1 Challenges of using DT in RIC

Success of research projects is measured mainly by numerical parameters such as number of publications, number of patents, number of spin offs and schedule fulfilment (Al-Ashaab, Flores, Doultsinou & Magyar, 2011, Langford, Hall, Josty, Matos & Jacobsen, 2006). This leads to a lower motivation to engage in creative and unknown/uncomfortable activities as already suggested by Pink (2011). We experienced that an established linear project process for RIC is contradictory to the principles of DT which require multiple short iterations and testing loops. However, we find that the mismatch of timelines in RIC with their long duration is even larger compared to the corporate context and that the challenge towards implementation of DT is proportionally bigger.

Our analysis shows that some of the identified challenges for using DT in RIC are comparable the those for the corporate context as described by Carlgren et al. (2016a). The specific characteristics for these challenges seen in the new context of RIC are described in Table 4.

Table 4. Types of challenges using DT in RIC compared to previous studies in corporate context

Known DT Challenges	RIC specific Description
Misfit w/existing Processes and Structures (Carlgren, 2016a)	Used to operating in linear project model, large independency and little co-creation.
Design driven vs. Data driven (Price et al., 2018)	Scientists and engineers educated to trust and generate quantitative data, skepticism to qualitative, explorative and visual data.
Resulting Ideas and Concepts difficult to implement (Carlgren, 2016a)	Nature of ideas and concepts often abstract and futuristic outside comfort zone, desire for perfect solutions right away.

Known DT Challenges	**RIC specific Description**
Value of DT difficult to prove (Carlgren, 2016a)	Not enough time/touchpoints in RIC to prove value of DT, bad experience with post it's
DT Principles/Mindsets clash with org. Culture (Carlgren, 2016a, Price et al., 2018)	Qualitative work, insecurity of the outcome and fun are not seen as serious research.
Existing Power Dynamics are threatened (Carlgren, 2016a)	Tenure and independent work of especially senior scientists less important in DT teams.
Skills are hard to acquire (Carlgren, 2016a)	No exposure to design or DT in scientist's education and bias towards DT.
Communication Style is different (Carlgren, 2016a)	Long texts and proceedings used for communication rather than visuals.
Cognitive Bias (Liedtka, 2015)	Looking for confirmation or invalidation of a set of hypotheses defined early in the research process. Not open for new solutions.

In our research we additionally identified six new challenges of using DT distinct for the context of RIC:

1. Discontinuity of Activities - One specific challenge of using DT in RIC is the discontinuity of activities and often only annual meetings between project members during the long project duration of four to six years. For example, it was difficult to continue working with material, i.e. personas or stories, developed in joint workshops early in the projects because the participants in the follow-up workshop had lost the empathic connection to the situation or we had different participants in the follow-up workshop that did not know the work we did initially. We observed that acquired DT skills are lost when not practiced in between the activities.

2. Lack of Credibility in the Research Field – The designers and DT facilitators in RIC were initially met with skepticism because the field of DT was new and unfamiliar to the participants. We observed a lack of credibility and trust especially for coaches and facilitators that did not have an education in one of the scientific fields of the RIC as illustrated by the following quote: *"They don't understand what our research is all about"* – scientist. Another explanation for the skepticism were negative previous experiences with creative techniques resulting in statements like *"I have been part of such (DT) processes internally but have usually never heard about it afterwards"* – product developer; *"I am allergic to post its – this doesn't lead to anything and I can spend my time better in the lab"* – researcher.

3. Tension between Intrinsic and Extrinsic Motivation – This may be one of the most fundamental challenges in academia-industry RIC going back to what Simons et al. describe as goals and motivations in R&D (Simons, 2011). The intrinsic motivation of researchers are knowledge generation and peer recognition. We heard statements like "*I just want to get my results published, that's how I am measured*" – researcher; or "*We cannot work like that because it is not publishable*" – scientist. Scientific publications are important for obtaining project funding and thus cannot be ignored as output measures. Industry participants of RIC often underestimate the need for extensive data collection and want to jump to a solution rather quickly as indicated by statements like "*When can we use the results to make a new product?*" – industry R&D manager. We experienced this tension being a barrier to using DT in early project phases but once established as mindset, DT was able to lower the tension by creating a common understanding of desired scientific and innovation outputs.

4. Extreme Diversity - RIC have an extreme variety of cultural differences as the members often come from multiple countries, organizations, sectors, and disciplines. Compared to the corporate context these transdisciplinary teams make it difficult to find a common language and even more difficult when bringing in the designer's unfamiliar mindset, language, and tools in addition. An illustrating example is the combination of microbiology, social science, educational science, policy, innovation management and design thinking in the *FoodSafety* case: in the early project phase a dictionary between disciplines had to be generated and a common language established to overcome this challenge. A statement by a researcher is *"I don't understand your* [the social scientist's] *way of working and terminologies, you make it so complicated and large"*, and vice versa about the microbiologist *"Things are much more complicated than what lab tests and numbers can tell, we need to do it our way"*.

5. Lack of "Bias for Action" – Science-driven and theory-driven linear thinking fosters data creation and often statistical proof instead of rapid prototyping and frequent testing with users. In all our cases we observed that it was difficult to engage in spontaneous or guided creative activities or activities involving users due to the fear of a) doing something wrong and b) doubting the value of the activity. One work stream leader stated after a persona and innovation workshop in the "Develop" phase of the *PlantProtein* RIC that *"It is so difficult to come up with things within such a short time, but I am getting used to it as we are using approaches like that in our project more often now. During my first experience I was totally lost"*. The bias for action and interest to try a different way of working was higher for younger, less established team members compared to senior scientists.

6. "Team by Law" - RIC teams are selected in each participating organization separately based on expertise in the field and availability without considering creativity/DT skills. Participation is often inconsistent over time and therefore it is difficult to fully embrace DT. RIC participants may have competing market interests which according to our observations leads to skepticism and closedness. This changed over time due to diverging or converging nature of the DT phase (Pabst, Drescher, Haendschke, Tyrasa & Gonera, 2018) and statements around openness and the wish to collaborate after DT workshops became common in diverging phases; "*We can be so proud of us. This was so good. What a feeling"* – project manager and *"I look forward to continued collaboration with you in the project"* – industry partner.

4.2 Enablers for using DT in RIC

The context and ecosystem in RIC are more complex compared to corporate environments due the extreme diversity described above, thus asking for a different practical approach to introduce DT. In the process of facilitating and studying DT in the five cases we derived and developed enabling approaches particularly important for the RIC context. These build somewhat on existing literature but differ from previously described enablers.

1. Experiential Learning – We used a "learning by doing" approach to implement DT to RIC as also described in other contexts (Price et al., 2018, Beckman & Barry, 2007, Rauth et al., 2015, Liedtka, 2018). Especially in early project phases it was crucial to have short DT lessons combined with practical workshops on the research topic of the RIC. Examples of these activities are building a joint project vision and roadmap, working with personas, user empathy exercises, and field trips. DT with its hands-on, co-creative methods contributed to the positive experience and fun in joint activities as indicated by the following quotes: *"This was the best session of the entire two days of the project meeting"* – researcher; *"This was fun, and I learned a lot"* – product developer. This again improves team building and collaboration across disciplinary boundaries. Keeping up the continuity of activities showed to be essential for the learning journey. DT is a methodology that leads to trust building, partnership and engagement in teams enabling a better innovation outcome (Liedtka, 2017). We observed that DT contributed to better collaboration in diverging project phases also between RIC participants that have competing interests: "*This time* (with DT) *we really experience the project as a joint project."* – industry R&D manager.

2. Change Agent / Design Innovation Catalyst – A process responsible who is actively driving DT engagement as also described by Price et al. (2018) is a key enabler of DT not only in corporate context but also in RIC. We found that this Design Innovation Catalyst (DIC) needs to have high credibility in the research field to be accepted and successful. The role of the change agent is to translate and facilitate design observation, insights, meaning, and strategy into all facets of the RIC. The role of the DIC is described by project members as *"uniting the language of the technology and the language of the user in the sense of a bridge builder" and to "facilitate and activate creativity and novel thinking and also generate a sense of [. . .] user needs".* In classical RIC this role is basically non-existent, and we are pioneering the approach by our research.

3. Gatekeeper / Advocate for DT – Especially during the pre-project phase, when the overall project approach is designed and in the early (discover) phase of the RIC, a strong advocate for DT was essential to enable the approach (Price et al., 2018). For all cases this was the responsible RIC project manager who acknowledged the potential benefits of using DT in this new context, trusted the DT facilitators in their capabilities, and communicated the importance of working according to DT principles. The role of DT advocate gradually developed into an ambassador network (Rauth et al., 2015) with increasing establishment and success of using DT. Project members started to talk positive about the DT activities to peers and leadership.

4. Established Set of DT Tools and Formats – We developed tailor-made methods in each of the RIC depending on the DT phase and respective challenges we worked on. Explanation of the process and coaching of DT proved especially important to create confidence and trust that the method will bring the team to the desired outcome. The establishment of a DT terminology in conjunction with other fields of the RIC as well the repetition of tools and terminology in a language that is understandable were important enablers. Visualization of the content and summarizing results in a tangible format supported the interest and engagement for DT. We found it particularly important to take research data into account and triangulate it to DT outcomes to improve credibility of DT and minimize the perceived risk when using qualitative methods.

ISSN 2183-0606
http://www.open-jim.org

Adapted DT tools and methods will increase the chance for reapplication and recognition of the methodology in the scientific community.

5. Team Reflexivity - Surprisingly we found that team reflexivity became more important for team performance and using DT in later DT phases. This is in contrast with a previous study by Seidel and Fixson (2013) who find team reflexivity important for novice DT teams especially in the early DT phases. One explanation could be that RIC participants first needed to get familiar with DT and the RIC team before they could develop team reflexivity from initial skepticism.

4.3 Benefits and Practitioner Implications for Research and Innovation Consortia

Successful innovation projects must deliver three things: superior solutions, lower risks and costs of change, and employee-buy in (Liedtka, 2018). Applying DT in RIC has the potential to encounter all of these outcomes. The benefits of using DT in our five RIC cases center around the key DT elements of empathy, visualization, and experimentation for superior solutions. Particularly the use of DT in the RIC funding application phase lead to an overall people-centric approach taking user needs into account and strongly focusing on innovation and (business) impact. We argue that this is a distinct quality and a novel unconventional approach compared to other research projects or consortia and can be further explored and exploited. One researcher summarized his experience after several DT workshops in *PlantProtein* RIC in the following way: "*I have never seen something like that, and I joined a lot of similar huge projects. This is just great and should be a role model for other projects. Others have to learn from what we are doing*".

Scientific RIC have the advantage that resilient studies and knowledge of the field are available already at the project proposal stage/early in the project thus strengthening the DT approach by enabling triangulation. This leads to a perceived risk reduction (through use of data) at the same time as it leads to improved innovation outcome (through use of creativity).

We believe that the use of DT in RIC leads to increased flexibility for the research and innovation process and outcome but to achieve this flexibility good process management and excellent capabilities of the Design Innovation Catalyst are necessary. Based on our findings, we suggest that complex RIC will benefit from an intermediary (DT) role translating research results into understandable and business-relevant information, and business needs into research questions in analogy to Wrigley's Design Innovation Catalyst (Wrigley, 2017). It is recommended that the DT facilitator works closely with the respective project manager to assure seamless execution but also have an important advocate and door opener.

We experienced in the projects that a more innovative and broader form of research result communication was achieved by using DT. In addition to the classical reports and publications also visualizations, physical prototypes, public events, exhibitions, and films were produced reaching a much broader audience compared to classical research projects. This is again in line with the funding bodies' ambitions for effective dissemination and implementation of research results.

In the projects were a continuous requested for DT facilitation occurred, project participants fully emerged into the DT mindset and developed employee buy-in: "*I was totally surprised by the power of testing prototypes and the willingness of giving feedback by users, thus I find myself questioning much more often.*" - research participant in one RIC.

The introduction and use of DT in RIC must be planned carefully considering the identified challenges. DT must be explained and demystified for scientists and practitioners who are not used to working user-centric, visual, co-creative and iterative so that it can become a respected way of working. Using DT requires sufficient time and resources, especially when the approach is new to the team. This calls for additional project budget with no direct scientific output and may therefore be difficult to justify.

4.4 Implications for Policy Makers

Several of the challenges of using DT in RIC are related to policy framework conditions. Public funding and reporting requirements determine which societal problems need to be solved, who receives funding, and how RIC success is measured. We must work with policy makers and educators to encourage and legitimize DT in RIC. For a successful implementation of DT in publicly funded RIC a change of KPIs for research projects is necessary shifting focus from only scientific contribution to real positive impact on people, planet, profit as also mentioned by Fisk (2010).

At the same time, a development from linear project organization and project reporting to a more dynamic and flexible form should be encouraged by the funding bodies. DT with its phases and elements could enable such a transition. The European Commission's "Implementing an Action Plan for Design Driven Innovation" (European Commission, 2013) aims to understand the impact of design on innovation and strengthen industry competitiveness through design-driven innovation. We observe the onset of that shift in public funding calls and at proposal phase where novel approaches (such as DT) are specifically encouraged, however during project reporting the paradigm shift has yet to happen.

An inclusion of DT skills, creative methods, and innovation studies in the education of scientists of various backgrounds is politically supported (European Commission, 2013). These ambitions have the potential to improve problem-solving skills, collaboration and innovation skills among scientists without compromising on the credibility of science.

5 Conclusion

This paper describes how we use DT in RIC in a systematic and continuous way and makes several contributions related to the potential role of DT as an approach to working in RIC. We identified unique empirically categorized challenges and enablers for using DT in joint academia – industry RIC.

The use of DT was challenging when first introduced to RIC as DT principles are contradictory to scientist's way of thinking and working. Through rigorously applying DT, using Design

Innovation Catalysts, adapting DT methods to the individual cases, and reflecting with the team on the use of DT in RIC we experienced true game-changer potential. There are several challenges to overcome to fully utilize DT's potential in RIC, some of them inherent to the way academia is performing R&D and some of them dependent on policy framework conditions. We suggest that complex RIC benefit from an intermediary (DT) role translating business needs into research questions, and research results into understandable and business-relevant information and innovation.

6 Limitations and Further Research

The results of the study are derived from five cases. The data collected strongly depends on the choice of cases and the persons and material included. In this study, the researchers themselves are action researchers facilitating the DT process at the same time as they perform the research. This means that we are not simply external observers but take a transformative orientation to knowledge creation that can only arise in the context of practice (Bradbury-Huang, 2010). This mode of research provides valuable first-hand insights and experiences enabling an immersive and holistic way of collecting data. We have incorporated learnings from our analysis into the projects immediately and thus achieve a better implementation of DT in RIC.

Methodologically, action research can bear the risk for limited precision in interventions including suboptimal research design as highlighted by the discussion of relevance and rigor in action research (Guertler et al., 2019). Within innovation projects that tackle real world problems, it is easy to rather focus on the problem to be solved than on the research or methodological perspective. Therefore, we emphasize action researchers for a strong self-awareness concerning proper research design and process advancement. Careful planning of the DT activities as well as the linked research is necessary. This was achieved by thorough project design of both the activities and data collection, frequent data analysis and reflection within each case and jointly across cases during the three-year timeline of the study. Shortening learning cycles, increasing the researchers' resources and focusing on an even stronger visualization for a more efficient reflection among research collaborators are some of our learning points.

We study all phases of the DT process and the methods/tools feasible to solve the respective innovation challenge of the case RIC. Not all case projects are completed at the point of analysis but have had at least three to four years of DT experience. Due to the explorative character of the study the results should be considered a "working hypothesis" (Guba & Lincoln, 1994). Our action research approach with its reflective nature as well as frequent validation and feedback with RIC project members lead to a pragmatic validity of the research results and we believe that our data is representative for an exploratory study in an area where cases and data are scarce.

The studied sample is not large enough to analyze for country or sector specific challenges. Based on our empirically derived data further research is needed to investigate in depth understanding of other cases and confirm our hypotheses. A quantitative study within the described cases and beyond could help to validate our findings. Further research is needed to understand specific aspects unique to RIC for example the role of the DT facilitator or the specific combination of disciplines in a project. As future research we highly encourage to study the use of specific DT tools and approaches in a context and project specific setting. As increased transdisciplinarity was only one aspect emerging as a benefit of using DT in RIC, future research should focus on better understanding the impact of DT on transdiciplinarity. As we found the pre-project phase and project set-up/start-up phases critical for defining common project goals, a common language across disciplines, and aligned on DT as way of working, more focus should be laid on DT stage-specific emerging patterns in RIC in future research. It would also be of interest to compare projects with and without DT as a pure case study (without the action research approach) specifically focusing on transdisciplinary collaboration, capability building and innovation outcome.

Further research studying innovation policy development concerning the use of DT in RIC could provide valuable insights leading to an increased implementation of DT into research-based innovation. This will also shed light on how the fundamental question of adapting incentives and measures for research and innovation projects may be addressed in future.

Acknowledgements

We thank the Norwegian Fund for Research Fees for Agricultural Products (FFL) supporting the study through the project "InnoFood" (NRC262303), the Norwegian Research Council for financial support of the projects "MATLYST" (NRC269077) and "FoodProFuture" (NRC267858), the European Commission for support of the project "SafeConsumE" (GA727580), and the German Federal Ministry of Education and Research (BMBF) with - Entrepreneurial Regions and their initiative "Twenty20" for the support of the research and innovation consortia "3Dsensation" including the "camera sensor" and "InnoFo3D"project.

7 References

Aguirre, M., Agudelo, N., & Romm, J. (2017). Design Facilitation as Emerging Practice: Analyzing How Designers Support Multi-stakeholder Co-creation. *She Ji: The Journal of Design, Economics, and Innovation, 3*(3), 198-209.

Aken, J. E. v. (2004). Management Research Based on the Paradigm of the Design Sciences. Journal of Management Studies, 41(2), 220-238.

Al-Ashaab, A., Flores, M., Doultsinou, A., & Magyar, A. (2011). A balanced scorecard for measuring the impact of industry–university collaboration. *Production Planning & Control, 22*(5-6), 554-570.

Alves, J., Marques, M. J., Saur, I., & Marques, P. (2007). Creativity and Innovation through Multidisciplinary and Multisectoral Cooperation. *Creativity and Innovation Management, 16*(1), 27-34.

Basche, A. D., Roesch-McNally, G. E., Pease, L. A., Eidson, C. D., Lahdou, G. B., Dunbar, M. W., . . . Wilke, A. K. (2014). Challenges and opportunities in transdisciplinary science:

The experience of next generation scientists in an agriculture and climate research collaboration. *Journal of Soil and Water Conservation, 69*(6), 176A-179A.

Beckman, S. B., Barry, M. (2007). Innovation as a Learning Process Embedding Design Thinking. *California Managment Review, 50*(1), 25-56.

Benard, M., & de Cock-Buning, T. (2014). Moving from monodisciplinarity towards transdisciplinarity: Insights into the barriers and facilitators that scientists faced. *Science and Public Policy, 41*(6), 720-733.

Bessant, J., Öberg, C., & Trifilova, A. (2014). Framing problems in radical innovation. *Industrial Marketing Management, 43*(8), 1284-1292.

Bradbury-Huang, H. (2010). What is good action research? *Action Research, 8*(1), 93-109.

British Design Council. (2015). Double Diamond Model. Accessed July 2019: https://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond

Brown, T. (2008). Design Thinking. *Harvard Business Review* (June).

Brown, T. (2009). *Change by design: How Design Thinking transforms organizations and inspires innovation.* New York: HarperBusiness.

Brown, T., & Katz, B. (2011). Change by design. *Journal of Product Innovation Management, 28*(3), 381-383.

Carlgren, L., Elmquist, M., & Rauth, I. (2016). Exploring the use of design thinking in large organizations: Towards a research agenda. *Swedish Design Research Journal, 11*(1), 55-63.

Carlgren, L., Elmquist, M., & Rauth, I. (2016a). The challenges of using Design thinking in industry - experiences from five large firms. *Creativity and Innovation Management, 25*(3), 355-362.

Carlgren, L., Elmquist, M., & Rauth, I. (2014). Design Thinking: Exploring Values and Effects from an Innovation Capability Perspective. *The Design Journal, 17*(3), 403-423.

Carlgren, L., Rauth, I., Elmquist, M. (2016b). Framing Design Thinking: The Concept in Idea and Enactment. *Creativity and Innovation Management, 25*(1), 38-57.

Cooper, R. G. (1990). Stage-gate systems: a new tool for managing new products. Business Horizons, 33(3), 44-54.

Eikeland, O. (2006). The validity of action research-validity in action research. Action and interactive research–Beyond theory and practice, 193-240.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

European Commission. (2013). *Implementing an Action Plan for Design-Driven Innovation. Commission Staff working document, EC SWD (380) final.* Brussels: European Commission.

European Commission. (2018). *A renewed agenda for research and Innovation.* Accessed July 2019:
https://ec.europa.eu/info/publications/renewed-european-agenda-research-and-innovation-europes-chance-shape-its-future_en

Fisk, P. (2010. *People planet profit: How to embrace sustainability for innovation and business growth)*, Kogan Page Publishers.

Flick, U., & Gibbs, G. (2007). Analyzing qualitative data. *Designing qualitative research, 104.*

Garousi, V., Petersen, K., & Ozkan, B. (2016). Challenges and best practices in industry-academia collaborations in software engineering: A systematic literature review. *Information and Software Technology*, 79, 106-127.

German Federal Ministry of Education and Research. 2012. *Twenty20 – The programme* retrieved from `https://www.unternehmen-region.de/en/twenty20---the-programme-2048.html`)

Guertler, M., Sick, N., & Kriz, A. (2019). A Discipline-Spanning Overview of Action Research and Its Implications for Technology and Innovation Management. *Technology and Innovation Mangement*, 9(4), 48-65.

Guertler, M. R., Kriz, A., McGregor, C., Bankins, S., & Bucolo, S. (2017). "And Action!" – Rigour Meets Relevance in Action Innovation Management (AIM). Paper presented at the The XXVIII ISPIM Innovation Conference, Austria, Vienna.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research, 2*(163-194), 105.

Huzzard, T., Ahlberg, B. M., & Ekman, M. (2010). Constructing interorganizational collaboration: The action researcher as boundary subject. *Action Research, 8*(3), 293-314.

Johansson-Sköldberg, U., Woodilla, J., Çetinkayav, M. (2013). Design Thinking: Past, Present and Possible Futures. *Creativity and Innovation Management, 22*(2), 121-146.

Kanter, R. M. (2006). Innovation The Classic Traps. *Harvard Business Review* (November).

Kimbell, L. (2011). Rethinking design thinking: Part I. *Design and Culture, 3*(3), 285-306.

Langford, C. H., Hall, J., Josty, P., Matos, S., & Jacobson, A. (2006). Indicators and outcomes of Canadian university research: Proxies becoming goals? *Research Policy, 35*(10), 1586-1598.

Leitner, K.-H., Warnke, P., & Rhomberg, W. (2016). New forms of innovation: critical issues for future pathways. *Foresight, 18*(3), 224-237.

Liedtka, J. (2015). Perspective: Linking Design Thinking with Innovation Outcomes through Cognitive Bias Reduction. *Journal of Product Innovation Management, 32*(6), 925-938.

Liedtka, J., Salzman, R., & Azer, D. (2017). Democratizing Innovation in Organizations: Teaching Design Thinking to Non-Designers. *Design Management Review, 28*(3), 49-55.

Liedtka, J. (2018a). Exploring the impact of design thinking in action. *Darden Working Paper Series.*

Liedtka, J. (2018b). Why Design Thinking Works. Harvard Business Review, September – Oktober 2018 Issue, 72-79.

Lindberg, T., Noweski, C., & Meinel, C. (2010). Evolving discourses on design thinking: how design cognition inspires meta-disciplinary creative collaboration. *Technoetic Arts, 8*(1), 31-37.

Mahmoud-Jouni, S. B., Midler, C, & Silberzahn, P. (2016). Contributions of Design Thinking to Project Management in an Innovation Context. *Project Management Journal, 47*(2), 144-156.

Mazzucato, M. (2018). Mission-oriented research & innovation in the European Union: A problem-solving approach to fuel innovation-led growth. Retrieved from https://ec.europa.eu/info/sites/info/files/mazzucato_report_2018.pdf

Norman, D. A. (2010). The research-Practice Gap: The need for translational developers. *interactions, 17*(4), 9-12.

Pabst, R., Drescher, M., Haendschke, S., Tyrasa, I., & Gonera, A. (2018). Temporal patterns of Open Innovation in Research and Innovation Collaborations Conference Paper presented at the ISPIM conference Fukuoka, Japan.

Pink, D. H. (2011). *Drive: The surprising truth about what motivates us*: Penguin.

Popowitz, M. & Dorgelo, C. (2018). *University-led Grand Challenges.* Retrieved from https://escholarship.org/uc/item/46f121cr

Price, R., Wrigley, C., & Matthews, J. (2018). Action researcher to design innovation catalyst: Building design capability from within. *Action Research*, 147675031878122.

Rae, J. (2016) Design value index exemplars outperform the S&P 500 index (again) and a new crop of design leaders emerge. *Design Management Review,* **27**, 4-11.

Rauth, I., Carlgren, L., Elmquist, Maria. (2015). Making it happen: Legitimizing Design Thinking in Large Organizations. *Design Managment Journal, 9*(1), 47-60.

Sandberg, A., Pareto, L., & Arts, T. (2011). Agile collaborative research: Action principles for industry-academia collaboration. *IEEE software*, 28(4), 74-83.

Sannö, A., Ericsen Öberg, A., Flores-Garcia, E., & Jackson, M. (2019). Increasing the impact of industry-academia collaboration through co-production. *Technology Innovation Management Review*, *9*(4).

Seidel, V. P., & Fixson, S. K. (2013). Adopting Design Thinking in Novice Multidisciplinary Teams: The Application and Limits of Design Methods and Reflexive Practices. *Journal of Product Innovation Management, 30*, 19-33.

Simons, S. M. R., Kimberly N. (2011). Diversity and its Impact on Organizational Performance: The Influence of Diversity Constructions on Expectations and Outcomes. *Journal of Technology Management and Innovation, 6*(3), 71-83.

Simons, T., Gupta, A., & Buchanan, M. (2011). Innovation in R&D: Using design thinking to develop new models of inventiveness, productivity and collaboration. *Journal of Commercial Biotechnology, 17*(4), 301-307.

Thompson, M. A., Owen, S., Lindsay, J. M., Leonard, G. S., & Cronin, S. J. (2017). Scientist and stakeholder perspectives of transdisciplinary research: Early attitudes, expectations, and tensions. *Environmental Science & Policy, 74*, 30-39.

Tidd, J. O. E., & Bessant, J. (2018). Innovation Management Challenges: From Fads to Fundamentals. *International Journal of Innovation Management, 22*(05), 1840007.

Tschimmel, K. (2012). Design Thinking as effective Toolkit for Innovation. Paper presented at the The XXIII ISPIM Conference, Barcelona, Spain.

Tushman, M. L., & O'Reilly III, C. A. (1996). Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review, 38*(4), 8-29.

UK Government. (2017). *UK Strategy for Global Challenges Research Fund.*

Van de Ven, A. H. (2007). Engaged scholarship: Creating knowledge for science and practice. *Oxford University Press, Oxford.* Accessed on May, 17, 2019.

Verganti, R. (2003). Design as brokering of languages: Innovation strategies in Italian firms. *Design Management Journal (Former Series), 14*(3), 34-42.

Verganti, R. (2008). Design, Meanings, and Radical Innovation: A Metamodel and a Research Agenda. *The Journal of Product Innovation Management, 25*, 436–456.

Wrigley, C. (2016). Design Innovation Catalysts: Education and Impact. *She Ji: The Journal of Design, Economics, and Innovation, 2*(2), 148-165.

Wrigley, C. (2017). Principles and practices of a design-led approach to innovation. *International Journal of Design Creativity and Innovation, 5*(3-4), 235-255.

Yin, R. K. (2017). *Case study research and applications: Design and methods*: Sage publications.

Zscheischler, J., Rogga, S., & Busse, M. (2017). The Adoption and Implementation of Transdisciplinary Research in the Field of Land-Use Science—A Comparative Case Study. *Sustainability*, 9(11).

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