Theory as Design Material: *How Design Researchers Use Design Skills to Explore the Malleability of Theory*

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Design researchers use theory in many ways in their design research practice. Bridging the gap between theory (as an abstract form of knowledge) and making design decisions can be challenging. Based on interviews with 10 design researchers, the paper examines the various ways they apply theory in designerly ways. The paper presents three interrelated findings that emerge from a thematic analysis. The first theme unpacks how theory use can be characterized by examining the malleability of theory. It describes how theory is explored and used as a design material, similar to other design materials like wood or textiles. The second theme explores how design skills are ways to activate the malleability of theory as design material. The third theme explores a variety of practices that the participants mention, as "ways of doing," in design research. The combination of these themes describes how designers use design skills to activate the malleability of theory as a design material, and they employ a variety of practices to achieve this. Finally, we reflect on what the findings mean for the future of design education.

Keywords **–** Activating Theory, Design Research Practice, Research through Design, Theory as Design Material, Theory Malleability.

Relevance to Design Practice **–** The paper describes how design researchers explore the use of various forms of knowledge, such as theory, through their design skills and design practices. It describes how they build with, combine, improve, and transition theory as design material. Furthermore, the paper highlights implications for the future education of design researchers.

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Introduction

Design researchers apply theories and various forms of knowledge[1] from diverse disciplines to inform the Research through Design (RtD) process. However, it can be challenging to bridge the gap between theory and design (Dalsgaard & Dindler, 2014; Johry et al., 2023). Common reasons given for why it is difficult to apply theory to design include practitioners having difficulty judging the utility of the information (Roedl & Stolterman, 2013), translating more abstract knowledge and theories into concrete design decisions for specific design situations (Dalsgaard & Dindler, 2014), and finally, that design practitioners may face a lack of time or funding (Beck & Ekbia, 2018).

While variations of terminology have been used to describe combinations of research and design, including constructive design research (Koskinen et al., 2011) and programmatic design research (Brandt & Binder, 2007), we will use the terms Research through Design (RtD) and design research (DR). According to Zimmerman and Forlizzi (2014), "Research through Design (RtD) is an approach to conducting scholarly research that employs the methods, practices, and processes of design practice with the intention of generating new knowledge" (p.167). Similar to Krogh et al. (2015), we view *RtD* as *conceptualizing research done by means of the skillful practice of design activity, revealing research insights*. Depending on the set-up of the project, an RtD project might lead to a combination of research insights, prototypes, and (the starting point of the development of) a bespoke or commercial product or system.

Engaging in DR, designers follow iterative cycles of generative and evaluative phases, where they shape ideas into designs and confront them with real-world contexts. Stappers (2012) visualizes this as an iterative spiral where theories and other forms of knowledge from adjacent disciplines interact and inform the designers' thinking. The diverse nature in which design practitioners use theory has also been acknowledged by Rogers (2005), who looked within the human-computer interaction (HCI) field, identifying functions that are descriptive, explanatory, analytical, formative, and generative.

Krogh et al. (2015) explored how designers engaged in RtD employ diverse drifting approaches in design experiments. These approaches result in the accumulation of knowledge through

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depth or stacking, recognition of complexity, and the extension of existing knowledge. Meyer and Norman (2020) emphasized the importance of designers incorporating methodological and theoretical knowledge of increasing complexity to address contemporary societal challenges. However, Beck and Stolterman (2016) highlighted the underrepresentation of how theory is applied in DR within the literature. Moreover, various review studies suggest that design researchers may not fully harness the potential of theory and existing knowledge to support their processes (Hassenzahl et al., 2012; Skovbjerg et al., 2021).

The role of theory-use in RtD remains understudied. The main approach so far has been to analyze descriptions of RtD in papers and theses. Inspired by Beck and Stolterman's idea of the everyday practice of theory use in DR (Beck & Stolterman, 2016), we aim to understand how theory functions in RtD projects. While Beck and Stolterman (2016) examine theory use in written reports of DR in journal papers, we focus on how design researchers explain theory use in RtD by interviewing them about specific projects. Following the approach of Dindler et al. (2022) of interviewing design practitioners to get a better understanding of how ethics is understood in practice, we interviewed design researchers with various experience levels to develop a better understanding of how theory is used in RtD projects.

Our research question is: *How do design researchers, with diverse backgrounds and experience, use various forms of knowledge, with a focus on theory, in their RtD (Research-through-Design) process?*

The aim of the work is not to prescribe how design researchers should apply theory but to unpack the practices of theory use.

Tilde Bekker is a full professor of Industrial Design at Eindhoven University of Technology, specializing in digital technologies for playfulness and motivation. Bekker's research focuses on creating theory-informed design tools and frameworks. She has co-developed two card-based design tools: the Lenses of Play and the Developmentally Situated Design tool. Her work also includes the development of toolkits that empower teachers and learners in design-based and challenge-based educational environments and of interactive play solutions for children. She is involved in various design and research projects, such as the Teaching More-than-Human Perspectives in Design (2022-2025) and Tools for Teachers and Learners (2024-2025).

Helle Marie Skovbjerg is a professor and head of research at the Lab for Play Design, Kolding School of Design, Denmark. For several years, Helle Marie has been developing the play mood perspective, a conceptual framework for understanding, exploring, and designing for play. She understands play as an existential way of being in the world, with people, materials, and relations explored in the book *On Play* (2021). She runs several research projects about play design, such as Playing Transitions (2023-2027), Playful Learning Praxis (2022-2026), and Learning Through Play (2022-2026).

Maria Lyndgaard Petersen holds a degree in psychology and is a scientific assistant at Aalborg University, affiliated with the Department of Communication and Psychology. She is currently finalizing her Ph.D. on the intersection of learning and performance in the workplace. Maria has been involved in several research projects and is responsible for data collection and processing in a large-scale study examining the role of culture and creativity for children and professionals in a school context. Her research interests are rooted in educational psychology, with a particular focus on the practical implications in educational settings.

Aakash Johry is an assistant professor in the Department of Design at the Indian Institute of Technology Delhi, where he leads the GAMES (Gaming, Augmented & Mixed-reality Experiences and Simulations) lab. His work focuses on designing serious games and playful technologies to study the affective and experiential layers of user experience and support design interventions related to play, learning, and healthcare. Within this broader agenda, his work aims to support the inclusion of marginalized populations.

Our work provides two contributions. First, we present three themes that shed light on how design researchers use theory uniquely to support design research's exploratory and generative nature. The contribution extends previous work in which DR practice was described in terms of drifting (Krogh et al., 2015; Krogh & Koskinen, 2020) and the ways in which theories are used in design (e.g., Beck & Stolterman, 2016; Rogers, 2005). Second, the three themes provide a perspective for further exploration of how designers use theory in their work, contributing to an academic discourse for discussing and engaging with DR practice. The results point to future work to examine the unique ways design researchers use theory and how to translate the insights into how we educate future design researchers.

Related Work

Different Forms of Theory and Knowledge

In examining how design researchers incorporate theory into their practice, we take a broad view of what can be considered as theory and knowledge in a DR context. We frame our understanding of knowledge and theory use in relation to the following work. First, similar to Beck and Stolterman (2016), we include theory or model to perspective, rationale, idea, process, and phenomenon in how we examine theory-use for the design researchers. Second, linking to the work by Höök and Löwgren (2012) and Dalsgaard and Dindler (2014), our understanding of theory and knowledge comprises different forms of knowledge within the space between abstract theories and concrete intermediary-level knowledge, such as strong concepts, design guidelines, and heuristics. Third, as DR is often an iterative process, it could be the case that the knowledge and theory that resulted from DR, can in turn be used for a next iteration of DR. For example, Krogh and Koskinen (2020, chapter 3) describe four concepts of knowledge as situated into things, into discourse, method and community. However, the focus of the present study is on how theory informs the DR process, and less on the outcome of DR.

Theory Use in Design Research

Rogers (2005) describes a shift in how theory is used in HCI work. While earlier approaches in HCI included informative, predictive, and prescriptive uses of theory, newer approaches shifted more towards analytic and generative uses of theory.

Dalsgaard and Dindler (2014) elaborate that theory-use in RtD can have different intentions and processes. They mention the work by Stolterman and Wiberg (2010) on developing conceptual constructs that start from theory and have the intention to contribute to theoretical advancement. They also describe the work by Höök and Löwgren (2012) on strong concepts that have the intention to distil intermediary knowledge by examining design cases. Their work has the intention to facilitate the exchange between theory and practice and is inspired by both exemplars and theory. Our work has a different focus: it points to the different roles that theory and knowledge can play in RtD, both in terms of where and why it is brought in, and in how it might be part of the intended outcome of RtD.

Research by Velt et al. (2020) examined how a specific HCI framework was translated to be used by design practitioners. Their research showed that the translation between research and design practice was approached through three different modes: a researcher-led, a designer-led translation, and a co-produced translation, following different trajectories between the higher-level theories, intermediated forms of knowledge, and linking them to concrete artefacts. Velt et al. (2020) distinguished between two gaps: 1) a gap that is linked to differences between communities of practice, the practices of the academic HCI community and the user experience (UX) design community; 2) a gap between general theory and particular artefacts or design solutions. Their model seems to imply that people reside either in the HCI community and do not work towards designs themselves, or that people reside in the UX design practice, and have no HCI-like background. DR practice includes many variations of how these two communities and their practices are combined, for example, including design researchers with a combined academic HCI and UX design practice, and thus potentially fulfilling both an HCI researcher and a UX designer role at the same time. Our work includes participants with interdisciplinary backgrounds and explores their DR practice and interaction with theory.

The starting point or intention of DR can vary. Bang et al. (2012) also point out that RtD can originate from different starting points, which they call *motivational contexts*: "we strongly support that design research be conducted by designers using design skills, and in order to underline this position we wish to acknowledge that motivations for both designing and researching can come from a number of sources" (p. 3). Based on analysis of 8 RtD theses, Bang et al. describe a set of 6 motivational contexts: practice-based/artistically inclined approach, an ethical, political, empirical, or technological provoked approach, and finally, a theoretically informed approach. These variations in starting points would also affect when and how researchers use theory across different stages of a RtD process. Krogh and Koskinen (2020, pp. 50-52) mention how design researchers often go through shifts in the focus of DR, which they call drifting. During these shifts, design researchers can realise that new theories are needed to further explore the new research direction. Through our exploratory study, we aim to capture these nuances by looking at the journey of various DR projects chosen by a diverse group.

Method

This study involves interviews with 10 design researchers working in academia. It explores how they use theory in their DR. This section presents our method in terms of data collection, interview protocol, analysis process, and limitations.

Data Collection

The interviews were set up following methodological considerations as described in Flick (2022). The participants are working in academia around the world, including Europe, the USA, and Canada. The interviewees (5 men and 5 women, see Table 1) were recruited based on diversity in amount of experience (having recently finished a PhD, having between 2 and 5 years of DR experience after finishing their PhD, having more than 15 years of experience) and diversity in background (e.g., combinations of design, computer science, HCI, and psychology) while working in academia.

Table 1. The 10 interviewees, their background, and their experience. Interviewees' information has been anonymized, and fictional names have been assigned.

Name	Background	Experience
1: Gary	Industrial Design	senior
2: Abigail	HCI, Interaction Design	middle
3: Bob	Media and game design	junior
4: Sophia	Industrial Design	junior
5: Owen	Physics teacher, HCI	middle
6: Lily	Computer Science, Engineering systems design, HCI	senior
7: Daniel	Sociology and Interaction Design	senior
8: Olivia	Interaction Design and HCI	senior
9: Richard	Art, philosophy and HCI	senior
10: Emma	Product design and Child-Computer-Interaction	junior

Interview Protocol

Following the semi-structured format, interviewees were given time and space to diverge from the specific questions if they had other dimensions to add to the topic. The interviews lasted between 60 and 90 minutes. The interviews were recorded and transcribed for analysis using the Dedoose ™ software.

The interviews were conducted by two of the authors and followed a semi-structured protocol. The interviewees were asked to select one of their projects as a reference point for the interview. The interviews began with broad questions about their background and their RtD process. Subsequently, questions were asked about the selected project, covering: the overall process and phases of the project, highlights of where existing knowledge was used, motivations for using knowledge, what knowledge was used, how it was used, perceived challenges of theory use, and the outcome of the project. Other questions addressed whether the way in which the theory was used in the selected project differed from other projects. The final questions addressed whether the participants saw value in scaffolding design researchers in using knowledge and theory.

Data Analysis

The analysis approach is inspired by constructivist grounded-theory methods (Charmaz, 2014; Salmona et al., 2019) and consists of a combination of initial coding, using open and orientation codes (Layder, 1998), and subsequent thematic coding of the interview data for directing the analysis of the material. The data was processed to be fully GDPR-compliant, including anonymization of the participants' names. When using quotes in the paper, we have substituted some recognizable concepts with more abstract words in between square brackets to ensure anonymity.

Following Charmaz (2014) and Layder (1998), we focused on the practices of the participants and their "doings" with their knowledge and theory use. When analyzing the empirical material, we followed Charmaz's bottom-up approach, letting the material talk and using insights from the open coding to point to the initial and thematic coding direction. The process of coding included several iterations between the authors, where parts of the material were coded by all the authors in collaboration, to examine whether the codes were adequate and to ensure a uniform coding practice. All the iterations were documented and logged in detail. In the first iteration of the open coding, we coded, amongst other things, types of knowledge used, when it was used, and practices of how it was used. For example, theory from psychology or domain knowledge could be used during ideation or evaluation, for conceptual development, or for sensemaking. We wrote memos as a part of the initial interpretation and in the following iterations to further develop the interpretation according to Charmaz, also supported by Redström's (2017) point about theory as something not always stable, but under continuous development. Later, we worked on the theme of malleability of the theory with several iterations among the authors to secure grounding and intercoder agreement (Campbell et al., 2013). Owing to the bottom-up approach, we have chosen to talk back (Beck & Stolterman, 2016) to the theories from DR in the discussion section, rather than in the results section.

Results

In this section, we first provide contextual information about the participants' selected projects to show the diversity of projects concerning domain, collaborations, outputs, processes, and the mentioned theory. Then we present three interrelated findings that emerge from our analysis (see Figure 1). Firstly, design researchers **use theory as a design material with malleability.** It means that theory is explored and used as a design material, similar to other design materials like wood or textiles, and it has malleable qualities. Secondly, design skills are used **to activate the malleability of theory as design material.** This means that it is through their design competencies that theory becomes relevant to design researchers. Third, we have identified **four practices as ways to activate the theory's malleability.** In the following, we will unpack those findings further. The practices are linked to different ways in which design researchers engage with the theory and how that way activates its malleability. In the following, we will unpack those findings further.

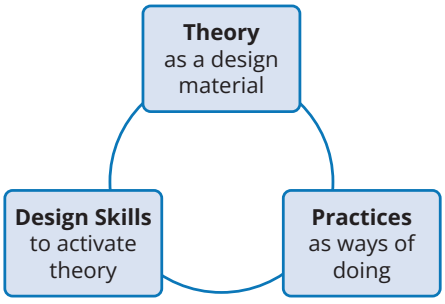

Figure 1. Overview of three themes related to theory use in RtD projects.

Contextualizing RtD Projects of Participants

The projects covered various domains, including learning, entertainment, sustainability, technology adoption, design tools, health, and well-being. The projects came from diverse contexts like schools, workplaces, libraries, museums, and urban communities, with prospective users including, for example, children and older adults. The projects included diverse design and research activities, such as exploratory research, ideation, user testing, field studies, observational studies, and effect studies. There were variations in approaches to the DR processes, such as practice-based/artistically inclined, theory-informed, philosophically, ethical, empirical, and technologically inclined projects. The projects also differed in the main output of the work, which included design knowledge, prototypes as proof of concept, and creating new design tools. Theories from different fields were mentioned, including psychology, sociology, philosophy, media studies, and design. Participants referred to different *types of knowledge*, including theories, frameworks, models, and concepts. These ranged from higher-level theories, intermediated forms of knowledge, and knowledge described quite close to concrete artefacts, such as design principles. Furthermore, the projects varied in how many people were involved and how long the projects lasted. Some were conducted mostly by one person, but they often discussed their work with fellow researchers and experts. Others were conducted with a larger team, with a more diverse set of skills and knowledge available within the team, such as (UX) designers, engineers, design researchers, and domain experts.

Theme 1: *Theory as a Design Material*

The first theme that emerged from the interviews shows that design researchers use **theory as a design material** across different points in their DR process. As stated by one participant, who read fundamental theoretical papers from diverse disciplines: "I think that I tried to make the literature a very concrete material in the design process" (Bob).

The participant states that he approaches literature as a concrete material, a design material, we could say, and it involves utilizing theory as a material in DR: appropriating it to align with the intention of the project and the studied context. We are defining this quality as the malleability of theory in connection to the specific context and DR intentions. It means it becomes a design material with malleability as a quality. This aspect of malleability is described by one of the participants, who explores applying theories from the HCI domain and cares about how design researchers can contribute to generating knowledge that supports making better designs, as follows:

> So you can, when you pick up a theory, you're going to see what it can do for you easily and also change it so that it does that bit for you. Rather than seeing theories sort of an absolute truth hanging out there. (Owen)

The participant mentions he is changing a theory, and we can say that an aspect of malleability is change, that you can explore what "theory can do for you," its malleability to your intentions. Its potential as a valuable design material is shaped by how it aligns with the goals and fulfills the external requirements

embedded in the process. If the theory cannot contribute meaningfully to the design researcher, it remains inaccessible for application; it cannot evolve into valuable design material. Approaching theory as design material and thinking about what to do with it also means that there is no truth hanging out there concerning the theory, as the participant states in the same quote. Instead, the job of the design researcher is to configure the DR intention and theory malleability in a meaningful way.

When the participant states that the theory is not "an absolute truth," we can understand the connection between the designer and theory as a negotiation, a dialogue between applicability and ability to find the meaningful configuration between DR intention and the theory's possible applicability. The possibility for interpretation is a core quality related to the malleability of theory. It means the theory is not fixed, and it is the considerations related to theory, applicability, and design intention that are combined. Another participant, who has a theory-driven approach to projects, reflected on the connection between the relevance of the intention and what to do with the theory when saying:

> Well, it's always hard. It is always hard to both understand if it might be relevant, and then if it is relevant, what do I do with it? I don't know if that makes sense, like so you know you can. You can know from [a science X and Y] about how you know how our bodies and brains are connected and how [a concept] plays out and all, like how that all works. But I go, what do I do with that as a designer? (Lily)

It is worth noting that the participant emphasizes the interpretation of a designer when making the connection between the relevance of the theory and its applicability. The fact that a designer searches for relevance related to the designer's intention and tries out its possible application, seems important for understanding theory use in DR. It also points to the importance of malleability of the theory as a quality for the designer to explore whether applying the theory will be valuable, and whether the opportunities that arise because of the malleability can be related to the intentions of the designer.

Theme 2: *Design Skills to Activate Theory*

Building on the first theme, the second theme indicates that design researchers **activate the malleability of the theory through design skills.** This means that for this quality of theory to find realisation, design skills are important. One of the participants, who gives examples of using theories from psychology and HCI when explaining the searching process for theories that are relevant and applicable for the design researcher: "I'll be a little bit pedantic. I think part of what you need to have there is also skills. I don't think that you can do Research through Design without skills in design" (Gary).

According to the participant, you cannot do research through design without skills. In light of theme number one, it means that in order to use the possible malleability of theory when it is design material, the design researcher needs design skills. What does it mean that the design researchers need to have design skills? It seems that the skills are used for interacting with and activating theory. It might be related to design skills like drawing, prototyping, or shifting perspective to try out the theory and explore its applicability. It is not only about cognitive abilities to explore if the theory works for the designer researcher's intentions, but also about using hands when examining how and to what extent a theory is relevant. That point is supported by another participant's comment, who points to design skills to test the application of theory (e.g., in translating theoretical concepts to design decisions) in a concrete way, when working with participatory design in DR: "Design skills can be used so that we can create this proof of concept, prototypes, and then actually test it in a very concrete way" (Abigail).

The participant mentioned both more global theories and specific concepts that are part of a theory or framework when giving examples of theory use in RtD. The design competencies mentioned make it possible for the designer to become concrete with the theory and to test to what extent it has potential for what is at stake. Later on, the participant points to the importance of design skills in relation to the (lack of) possibilities of different (less design-oriented) research methods. A pragmatic approach guides the intention in combination with the research question. The participant continues:

> Design skills can be used so that we don't just have to follow the conventional kind of traditional methods like interviews. They really often come up with their own, kind of like methods for trying to gain traction to their own research questions, right? So, I thought that was a very unique way how design researchers approached design use, making use of their skills. (Abigail)

Using design skills like making or drawing to activate theory through method use and method creation allows the design researcher to make theory accessible and, by that accessibility, explore the malleability of the theory. As the participant mentioned, these methods use design skills that are different from interview methods. As with design, the possibilities of incorporating 'making' and exploring different materials allow for other ways to be involved with theory.

Theme 3: *Practices as Ways of Doing*

The third theme builds upon themes 1 and 2. Theme 3 addresses several practices that the design researchers are engaged in. We can understand these **practices as ways of doing**, which activate the malleability of theory as design material. We have identified the following four practices in which they use their design skills: *building with theory, combining theory, improving theory, and transitioning theory* in using it as a design material.

The verbs come directly from the participants (Charmaz, 2014), and we developed them further into analytical categories for us to understand the nuances of practices. In the concrete empirical design practice, they can be understood more as a spectrum or space that covers applying theory almost one-to-one (*building with theory)* to putting things together that are not necessarily thought of as being together *(combining theory),* changing some elements but still within the same understanding *(improving theory)* to changing the theory in order to use it for a new purpose *(transitioning theory)*.

In the following, we will unfold each practice and present examples to make the nuanced differences between those practices clearer.

Building or Combining with Theory as Design-Material

The first two practices are *building with theory as design material* and *combining with theory as design material*. The former practice addresses when the design researcher is building the (new) theory. The design researcher is taking theory, using the elements that the theory has, and applying them in their project. The design researcher is not changing theory, but using it as it is. Often, the theory comes from the same research domain, such as developmental psychology or cognitive science. Within that research domain, the design researcher is applying theory as it is. As one participant mentions, when reading about theories, and then applying what has been read:

> So, if I were giving shape or if I was giving shape to a physical thing then I would use physical materials to create that thing right? But here I'm creating a conceptual thing, so I have to use some materials that are also abstract in nature and I extract those materials from the literature because those are the theoretical concepts in the literature that I use. So I basically go hunt for the things that I need, the concepts that I can mould. And then I extract them from the literature, and then I start working them into something that I find to be interesting to experiment with in relation to design practice. (Bob)

The participant shows that he is extracting from the theory he reads and then starts using it. The participant pointed to specific concepts of theory as things that I needed, and then the participant could build and arrange from there. The participant compares literature concepts with the physical materials used when designing a product. When using the concepts in the research work, the participant compares it to moulding and how he can mould with theoretical concepts.

The second practice we call *combining different theories as design material*. The practice is reflected when the design researcher combines theories that are not necessarily meant to be combined, e.g., when combining a concept from HCI with a concept from developmental psychology. It is not necessarily meant to be combined, but design researchers do it without changing the elements of the theory. Design researchers underline combining different design materials of theories as a core practice when using theory in their work. In describing the overall DR approach, related methodologies and theory use, one participant mentions:

> That way it's like figuring out what I wanna do and what I know and what I don't know and then how to come about it. But it's always this combination of existing knowledge and new knowledge and users. Always those three things together. (Lily)

Combining and combinations are core elements to the design researcher, and as the participant mentioned here, it is related to trying it out and seeing what happens. It often leads to unpredictability, as another participant, who is involved in projects with partners from diverse disciplines, states:

> I think I never had a clear agenda in my process and to be honest, I think it's not the ideal thing and it is often perceived as Research through Design is unpredictable. But I think it can be at certain points, like you present the object, understand something, synthesise that knowledge and then to another round of iterations. (Emma)

The participant also points to the emergent and exploratory nature of RtD, where objects (artefacts) can be manifestations of combining theories to understand and synthesise how theories can be used, trying out first this and then that to explore the possible different combinations. It would be impossible to predict those combinations beforehand: it is trying to combine, which is the practice. In relation to those combinations, another participant points to the question of outcome and rigor, and the surprises of combinations when thinking about the outcome of DR work:

> [...] Some of the best design examples in literature, they really come from strange places, I mean. And people are doing marvellous research based on the best psychological theories. [..] But then people are doing marvellous work based on whatever. It doesn't really matter as long as the outcome is good. Inspirations can come from anywhere, but then when you do a design process, the tools have to be, tools have to be more or less good because otherwise the outcome won't be good. (Daniel)

The participant is pointing out that design researchers bring in theory from different domains, following the previously mentioned quality of malleability by combining, including "strange places," indicating that the focus of the design researcher is towards the outcome, not necessarily knowing the outcome, but working towards some outcome. It is possible that the outcome based on the design intention could be distant from the specific theory or its original knowledge domain. As another of the participants, who works on a project in which many explorations are conducted in parallel and serial sub-projects, mentions, reinterpretation of theoretical concepts when combining is a part of doing DR and using theory:

> You might sometimes get sort of an explicit reinterpretation of a concept in the context of design, so that through examples and through remarks you get that, OK, so mimicry typically is this, but in design like this it could be like this. (Richard)

Following the participants, we can understand the malleability of the theory as the possibility for reinterpretation when combining.

The possibility of reinterpretation and the fact that those reinterpretations can come from strange places when combining are also supported by how DR is most often organised in multidisciplinary teams. On the one hand, it means access to knowledge from different fields when searching for ways to activate the malleability of theory, and on the other hand, constant possibilities of reinterpretation of the theory depending on which domains the interpretation comes from, or are created for. As Olivia, who works on a large project in a real-world context, explains: "We use a lot of models from social psychology, but also another tradition we could talk about is constructivism from Dewey." (Olivia)

Olivia specifically mentions how combining often means crossing over scientific paradigms, and when combining that is a common way. Another participant, who mentions that when he works on something new, he branches out to other fields, states that research is always done by exploring knowledge from "[…] bigger communities and then try to sort of rearticulate that in design research terms." (Daniel)

When Daniel is rearticulating the theory, we can say, he is reinterpreting it in connection to what the design intentions are, together with his team. The reinterpretation becomes a central part of the design research process when combining theory. A third participant, exploring how several concepts linked to an overall theoretical framework can be applied in DR, explains that further:

> We basically did a session in which we talked about interpretations of [concept A], right? So, we have kind of made it more explicit like our, this is how you think of that, and this is what kind of plans we do, we distinguish. (Owen)

The participant explains that the team works together and suggests different interpretations to combine different theories as design materials ends up with a shared reinterpretation of [concept A] to create one they agree on. Lastly, another participant points to the difficulties of that by saying: "I had to tap into a lot of, you know, very complex political literature, and also legal literature. So there we had a big team" (Abigail).

Combining different theories as design materials is a possibility for the use of theory in DR because of the nature of interdisciplinarity, but it also points to challenges for the design researcher and the design field. We will get back to that in the discussion.

Improving and Transitioning Theory as Design Material

This brings us to two more ways in which the design researcher uses the theory's malleability through design skills. These move to a higher degree of interpretation and change of the spectrum than the previous two. The third practice we call *improving theory*. That practice includes when the design researcher is expanding the theory so that it improves and works better for the sake of the DR. The fourth practice we call *transitioning theory*. That practice includes when the design researcher is expanding and changing the theory radically, so it works better for the sake of DR, but it does not necessarily align with the original intention. Whereas the practices of *building theory* with theory and *combining theory* stay within the core grounds or shapes of the understanding of the theory, *improving and transitioning theory* move beyond the original intention of the theory and thereby change the shape of the theory.

Those last two ways can be seen as radically different ways of reinterpretation of the theory. The designer expands what was originally meant by or understood through the theory, and expands the understanding for the sake of the outcome of the DR. This participant talks about DR as a way for the design researcher to improve theory:

> But yeah, in the end we did use the theories and both as a way of, or at least a source of inspiration for the theories that we devised ourselves. And also, our experience with designing with the theory, we used it, we didn't write so much I think about it in the paper but we did. So, we tried to basically, to *improve the theory* in a way that's more suited to the type of use that we wanted to do, that's in the end. (Owen)

The participant talks about *improving the theory*, and that the improvement is to make it more suitable. The participant emphasizes that it is important that the improvement is not for the sake of the theory, supporting the importance of the outcome of the DR when using theory. Instead, the improvement is for the sake of the design intention in combination with the need for the context:

> What we do here, for instance, is to create a questionnaire that would help students comment on [concept A] and see if we could make that concept measurable in some way. So that, in any evaluation you could say, oh, we succeeded in achieving the aesthetic of [concept A]. That was kind of our goal there. So then we ended up making the theory more formal again. Right saying, oh, how would this [concept] kind of play out in the actual experiences that students can understand? And that was quite and yeah, that then this *transition of theory* that you used needed to be precise. So, then you end up with this very fuzzy kind of theory here, you're degrading it because you're basically saying, okay, it was kind of fuzzy. It had multiple interpretations, but now we're going to make fixed interpretations, right? So, in a way, we then kind of, you have made it, we might disable others to use it in a generative way, because we were trying to use it as an evaluative framework as well. (Owen)
>
> (Note: the specific name of the concept was switched for the abstract [concept A] to keep the participants' anonymity.)

The participant talks about the *transition of theory* to describe the way the original theory evolves into other interpretations as the DR work develops. Therefore, the theory ends up being a "fuzzy kind," as the participant explains. The theory needs to be improved both to approach theory as a design material and to test its durability and suitability for different purposes in the DR process. This shows the need for design researchers to have the courage to see what happens when doing that, not to go with "fixed interpretations," as the participant states, but to have the guts to *transition theory* design material for the DR, often, even though the origin of the theory is something else. As described by one participant as being comfortable with "wading in deep waters" as a design researcher attitude:

> But also I needed that, right? Like there's something about wading into deeper waters and you know figuring out how to 'swim' through. That can be really informative and empowering but that doesn't mean that that's useful or nice for everybody. (Sophia)

The attitude of staying there even though it is not nice and potentially difficult to be in the messiness, is pointed to as a design researcher's competency as a part of the possibility of getting access to the malleability of theory and being able to approach theory as a design material.

Summary of the Four Practices and the Related Properties of the Practices

To summarise our current understanding of the four practices of how designers engage with theory, Table 2 gives an overview of the properties of these practices. Since we discovered these practices based on our data and did not have this specific focus when conducting the interviews, we have no data to describe how these practices might play out within one project.

However, the practices can be illustrated by the following hypothetical example, in which theories have been used in terms of combining and transitioning theory, in ways that change what the original theory was about. Based on the following existing theories:

1. A sociological theory of how children develop social play skills (Parten, 1932). Children go through stages in which these skills gradually shift from individual play to social and collaborative play.
2. An anthropological and sociological theory linked to the fact that play can vary from having hardly any predefined structure, rules, and goals (paidia) to having a lot of structure, rules, and goals (ludus) (Caillois, 2001).
3. Theory about how different levels of intensity in physical activity provide positive benefits for healthy behaviours (Jamnick et al., 2020).

It would be conceivable that practitioners would develop the following theories with changes to what the original theory was about:

- **Theory combined** (based on 1 and 2) of designing for variations of a combination of variations of social play AND variations in the amount of provided structure, rules, and goals.
- **Transitioned theory** (inspired by 1 and 3) through combining the concept of time and longer-time use, of flexible and diverse longer-term play trajectories, with diversity in levels of physical intensity, with diversity in social play types and practices for shifting between levels of physical intensity and social play types.

Discussion

The three themes contribute to an initial understanding of how design researchers use theory as a design material and how using their skills makes theory actionable as design material, with malleable qualities, operationalised through four different practices. Together, they shed light on the nuances of how design researchers articulate their use of theory. In the following, we discuss those insights linked to literature about bridging the theory-practice gap, how to make knowledge actionable, and lastly, how the experiences of design researchers are related to working in an interdisciplinary and cross-domain field of research.

The Theory-Practice Gap

The debate on bridging the theory-practice gap (e.g., Beck & Ekbia, 2018; Dalsgaard & Dindler, 2014; Roedl & Stolterman, 2013) mentions challenges of discovering how abstract theory can be linked to making design decisions and how to determine the utility of theory. Previous works by Krogh and Koskinen (2020) and Brandt and Binder (2007) have examined the design process in terms of different design experiments and iterations.

Table 2. Overview of four practices as ways in which design researchers activate theory as a design material.

Description of how properties of the practices are expressed	Type of practice			
	Building with theory as design material	**Combining theory as design material**	**Improving theory as design material**	**Transitioning theory as design material**
				
Activating theory linked to design intentions.	Building in a predictable way.	Combining in ways that is more surprising.	Improving and expanding theory through the design skills, and improving in a way so it supports the design intentions. Caring for design intentions, not necessarily only for the theory in itself.	Transform and change the theory–so it is not necessarily recognizable, for the sake of the design intentions.
Selecting theories and, or concepts based on literature related to various fields.	Often staying within a specific research field like psychology or computer science, and one scientific paradigm.	Putting theories together that can come from different fields. Often working across fields, for example across educational science and computer sciences.	Improving theory as design materials can both take place within a specific knowledge domain, and across knowledge domains.	Transitioning can both take place within a specific knowledge domain, and across knowledge domains.
Ways of combining from: **• Multiple theories,** **• From similar to more diverse disciplines.**	Stacks concepts from the theories.	Combines concepts from the theories.	Improves, or moves beyond the original intention.	Transforms the original intention from both theories to the combined design intentions.
	Not moving away from the original intention of the theory. Applying it to support the design research work.	Being creative with the theory by bringing things together in a surprising way.	Being creative by expanding and tweaking for the sake of the design intentions.	Being creative with the theory used, potentially involving breaking scientific codes (connected to the paradigm linked to that theory).

Note: The manner in which the qualities of the practices play out in the four practices is not seen as fitting very strictly to one of the practices, but is seen as a continuum, as is indicated by the arrow.

This study sheds light on some strategies that designers apply in their attempts to bridge theory to actionable design decisions and to examine the suitability of a theory in the messy process that leads developing a prototype. By zooming in on these practices, we state that design researchers find ways to the theory through their skills. It adds interesting reflections to the theory-practice gap discussion, because we might think about the bridging by looking at the designer's skills, not necessarily only at the quality of the theory.

Exploring the Malleability of Theory

We use the metaphor of theory design-material to give form and compare theory use with designers exploring whether and how to use a particular material in their process. Rather than treating theory as fixed and neutral, these practices suggest that, from a designer's perspective, theory possesses a certain inherent malleability, indicating that it is not merely a static entity but can be actively shaped and manipulated by the design researcher's skills. Stolterman and Wiberg (2010) mention that in a design-oriented field, where theorising includes concrete and creative design elements, theorising should not be seen as mechanistic, having a more static quality, but be seen as a sense-making and dynamic process.

We further unfold how those practices utilize skills. At the same time, theory pushes back at the DR practice in negotiation, and interpretations through the intentions of the design researcher. Each of these practices prompts consideration of whether the theory inherently demands specific modifications or if its utilization is contingent on the intentional choices made by the designer. This perspective underscores the dynamic and interactive relationship between the design researcher, the skills, the intentions, the practices, and the theory as design materials. In looking at theory use it is important to be sensitive towards what the theory is about, i.e., about its purpose. For example, the original theory might be about stages of cognitive development, while an improved theory might include both interaction design qualities inspired by the original theory, combined with how design decisions can support shifting between stages of development. In examining the practices of theory use, it would be interesting to examine in more detail how designers adjust the purpose of the theory through empirical and theoretical explorations.

Traditionally, the role of materials has been acknowledged and explored in the product design process, focusing on its technical properties, physical and sensorial qualities, and intangible characteristics like expression and meaning (Karana et al., 2008). A designer needs to acquire knowledge of a particular material. Just as you cannot do everything with wood or textile, it might be similar to a specific theory. Or another way of asking: Are there limits to the malleability of a sudden theory? To be able to answer, the designer would need to explore the suitability and potential use for their project by trying it out with the design material of theory in their hands, and it would be the negotiation and reinterpretation between theory, design skills, and design intention that would lead to answers.

In being able to do so, a design researcher has to acquire knowledge about the theory's *properties* and discover ways in which it can be built with, combined, improved, or transitioned to determine whether it is a good fit for their project. Hallnäs (2011) discusses giving form in interaction design through four dimensions: timing, spacing, connectivity, and methodology. Design researchers may also use theory as a design material to build spatial constructs (e.g., physical and geometrical features) and temporal constructs (function and behavior in use) of their design.

Doordan (2003) explores the concept of *material* in design from a design history perspective and points to the need for the designer to develop skills in how to use the material. He provides a framework for discussing *material* use in design, including fabrication, application, and appreciation (of materials). The distinction between fabrication and application is especially interesting in light of this paper, as it indicates that material is not only applied, but applying material is preceded by fabrication. The four practices can be seen as fabrications of the theory as design material in different ways: from very little fabrication to the total re-fabrication of the theory as design material.

These are examples of how designers incorporate various (new) design materials, learn how to embed them in their design practices, and point towards the relationship between the materials, the skills that designers apply, and the practices developed to explore the uses and flexibility of the materials.

Participants used various words, including verbs, to indicate how they interact with knowledge and theory. We have translated these into an initial set of 4 practices. We are aware that the nuances of these practices need further development. The way in which designers interact with theory has certain qualities, and we are still discovering these qualities and searching for how best to describe them. The participants worked on quite diverse projects. Various factors can influence how they perceive and use theory, such as the experience and expertise of the people involved in the project, the intended outcome of the project, and the project's duration. We have presented an initial understanding of theory use by RtD practitioners, but have not yet touched upon the relationships between contextual factors of RtD projects and particular forms of theory use.

Diversity in Levels of Expertise and Types of Projects

We interviewed design researchers with different levels of expertise (Albers et al., 2012) and different backgrounds, distinguishing between beginners and expert design researchers (see Table 1). More experience in searching for and selecting theory plays a role in how design researchers interact with theory, more experience and design skills in how to explore the relevance of theory, more experience in the diversity of theory, different ways to explore suitability of theory, and finally maybe also the courage to explore the use of theory and knowledge beyond what it may have been initially intended for can play a role. Experts are likely to have a more extensive repertoire of practices that they can apply, going to a greater extent for improvement and

transitioning of theory design material. Beginners might search for and select what they already know, staying within one research domain, aiming at building or combining practices when using theory as design material.

Krogh and Koskinen (2020) mention that constructive DR mainly takes place in the domains of engineering, design, and HCI. In this study, we have representatives of all three domains, but there are fewer design researchers from the engineering community (Table 1). The participants stated that they often collaborate with others when they do DR and then also work across domains, either discussing it with others or working closely together in larger teams of people with diverse skills. That influences how they use their skills, bridging theory and practice, and to what extent they can build with, combine, improve, or transition theory design material. Design researchers do not only use theory from the HCI domain, but also from other domains, such as social science. Relating this to how designers explore the malleability of the theory means that they need to practice and develop a rich set of strategies for applying design skills to 'theory as a design material,' identifying properties and affordances from different domains.

Apart from different outcomes, projects also varied in terms of their intentions. Was it initiated mostly from a research interest, in combination to deliver a potential (bespoke) solution, or was a different intention influencing the design intention? Bang et al. (2012) mentioned six different motivational starting points for RtD projects. Also, the six different ways of drifting described by Krogh and Koskinen (2020) point toward the wide variety of paths a DR project can take. Our exploratory study has examined theory use in a wide spectrum of projects, without examining in detail whether different types of projects influence theory use. It points to the importance of addressing these different intentions and the complexity of projects. We need to ensure that we are developing nuanced perspectives for examining the motives and assumptions from which the design researcher engages with theory use in their research practice.

Implications and Future Directions

In summary, our work has contributed to conceptualizing DR practices regarding how design researchers use theory as design material, and displays the need for more research:

- **Theory as a design material:** Design researchers are creative in using theory and knowledge, searching for its malleability. It raises questions about what we can do with theories and according to whom. Are there certain qualities that influence how applicable or malleable a theory is? How much knowledge do design researchers need about the knowledge applied to be critical about their usage of the practices of *building with, combining, improving,* and *transforming theory* to inform DR? When is an application of theory beneficial? How does the nature of a project and practice influence how theory is perceived and used?
- **Theory activation, design skills, and practices:** It raises questions about what designerly research skills and practices are and what skills are needed for theory activation, more specifically. How do design researchers explore the suitability and actionability of theory, and how do design skills play a crucial role in this process?
- **Design researcher's skills:** The skills can be seen as something other than generic research skills, but as skills unique to designers. It raises questions about the need to develop ideas on how we educate designers to develop those skills and practices, and nurture courage towards using theory as design material.

Conclusion

In this paper, we have reported an interview study with ten DR practitioners with different levels of experience exploring how they incorporate and use various forms of knowledge, with a focus on theory into their DR practices. Our analysis shows that theory use has unique qualities in the context of DR as it is used in a creative and generative manner and not only for descriptive or prescriptive purposes. We provide **two main** contributions:

The results shed light on the unique ways design researchers see theory as a form of malleable design material that can inform and inspire DR. This includes taking liberty with the original framing of theory to explore how it can inform their work, which can include using the theory beyond its original intention. Furthermore, the results show that design researchers apply designerly skills to make the theory actionable by using the spectrum of the following practices: *building with, combining, improving,* and *transitioning theory* as a design material.

Our results provide directions for future research related to the challenges for design researchers to use theory in their work. It would be interesting to investigate what aspects of design are informed and stimulated by theory design-material, like the discourse on giving form and expression in interaction design. An in-depth understanding of both challenges and possibilities can also provide insights into how design education can be adjusted in the future.

End Notes

1. For the purpose of this paper, we consider knowledge to be a broader concept than theory. While theory is one specific form of knowledge, knowledge itself can take many forms. To simplify our writing, we will use the shorter phrase "knowledge and theories" when referring to both concepts throughout the rest of the paper.

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References

1. Albers, A., Tarak Turki, T., & Lohmeyer, Q. (2012). Assessment of design competencies by a five level model of expertise. In *Proceedings of the 14th international conference on engineering and product design education* (pp. 305-310). The Design Society.

2. Bang, A., Krogh, P., Ludvigsen, M., & Markussen, T. (2012). The role of hypothesis in constructive design research. In *Proceedings of the 4th conference on the art of research.* University of Southern Denmark.
3. Beck, J., & Ekbia, H. (2018). The theory-practice gap as generative metaphor. In *Proceedings of the SIGCHI conference on human factors in computing systems* (Article No. 620). *ACM.* https://doi.org/10.1145/3173574.3174194
4. Beck, J., & Stolterman, E. (2016). Examining practical, everyday theory use in design research. *She Ji: Journal of Design, Economics, and Innovation, 2*(2), 125-140. https://doi.org/10.1016/j.sheji.2016.01.010
5. Brandt E., & Binder, T. (2007). *Experimental design research: Genealogy intervention argument.* Paper presented at the IASDR Congress, The Hong Kong Polytechnic University, Hong Kong.
6. Campbell, J. L., Quincy, C., Osserman, J., & Pedersen, O. K. (2013). Coding in-depth semistructured interviews: Problems of unitization and intercoder reliability and agreement. *Social Methods & Research, 42*(3), 294-320. https://doi.org/10.1177/0049124113500475
7. Charmaz, K. (2014). C*onstructing grounded theory.* Sage Publications.
8. Caillois, R. (2001). *Man, play and games.* University of Illinois Press.
9. Dalsgaard, P., & Dindler, C. (2014). Between theory and practice: Bridging concepts in HCI research. In *Proceedings of the SIGCHI conference on human factors in computing system*s (pp. 1635-1644), ACM. https://doi.org/10.1145/2556288.2557342
10. Dindler, C., Krogh, P. G., Tikær, K., & Nørregård, P. (2022). Engagements and articulations of ethics in design practice. *International Journal of Design, 16*(2), 47-56. https://doi.org/10.57698/v16i2.04
11. Doordan, D. P. (2003). On materials. *Design Issues, 19*(4), 3-8. https://doi.org/10.1162/074793603322545000
12. Flick, U. (2022). *Doing interview research: The essential how to guide.* Sage Publications.
13. Hallnäs, L. (2011). On the foundations of interaction design aesthetics: Revisiting the notions of form and expression. *International Journal of Design, 5*(1), 73-84.
14. Hassenzahl, M., Heidecker, S., Eckoldt, K., Diefenbach, S., & Hillmann, U. (2012). All you need is love: Current strategies of mediating intimate relationships through technology. *ACM Transactions on Computer-Human Interaction, 19*(4), Article No. 30. https://doi.org/10.1145/2395131.2395137
15. Höök, K., & Löwgren, J (2012). Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Transactions on Computer-Human Interaction, 19*(3), Article No. 23. https://doi.org/10.1145/2362364.2362371
16. Jamnick, N. A., Pettitt, R. W., Granata, C., Pyne, D. B., & Bishop, D. J. (2020). An examination and critique of current methods to determine exercise intensity. *Sports Medicine, 50,* 1729-1756. https://doi.org/10.1007/s40279-020-01322-8
17. Johry, A., Bekker, T., & Skovbjerg, H. M. (2023). Facilitating use of existing knowledge in research-through-design: A case study with design students. In A. Chakrabarti & V. Singh (Eds.), *Design in the era of industry 4.0* (vol. 3, pp. 725-238). Springer. https://doi.org/10.1007/978-981-99-0428-0_59
18. Karana, E., Hekkert, P., & Kandachar, P. (2008). Material considerations in product design: A survey on crucial material aspects used by product designers. *Materials & Design, 29*(6), 1081-1089. https://doi.org/10.1016/j.matdes.2007.06.002
19. Koskinen, I., Zimmerman, J., Binder, T., Redström, J., & Wensveen, S. (2011). *Design research through practice: From the lab, field, and showroom.* Morgan Kaufmann.
20. Krogh, P. G., & Koskinen, I. (2020). *Drifting by intention.* Springer.
21. Krogh, P. G., Markussen, T., & Bang, A. L. (2015). Ways of drifting–Five methods of experimentation in research through design. In A. Chakrabarti (Ed.), *ICoRD'15–Research into design across boundaries* (vol. 1, pp. 39-50). Springer. https://doi.org/10.1007/978-81-322-2232-3_4
22. Layder, D. (1998). *Sociological practice: Linking theory and social research.* Sage Publications.
23. Meyer, M.W., & Norman, D. (2020). Changing design education for the 21st century. *She Ji: Journal of Design, Economics, and Innovation, 6*(1), 13-49. https://doi.org/10.1016/j.sheji.2019.12.002
24. Parten, M. B. (1932). Social participation among preschool children. *Journal of Abnormal Psychology, 27*(3), 243-269. https://doi.org/10.1037/h0074524
25. Redström, J. (2017). *Making design theory.* MIT press.
26. Roedl, D. J., & Stolterman, E. (2013). Design research at CHI and its applicability to design practice. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 1951-1954). ACM. https://doi.org/10.1145/2470654.2466257
27. Rogers, Y. (2005). New theoretical approaches for human-computer interaction. *Annual Review of Information Science and Technology, 38*(1), 87-143. https://doi.org/10.1002/aris.1440380103
28. Salmona, M., Lieber, E., & Kaczynski, D. (2019). *Qualitative and mixed methods data analysis using Dedoose: A practical approach for research across the social sciences.* Sage publications.
29. Skovbjerg, H. M., Bekker, T., d'Anjou, B., Johry, A., & Quinones, K. K. P. (2021). Examining theory use in design research on fantasy play. *International Journal of Child-Computer. Interaction, 32*, Article No. 100400. https://doi.org/10.1016/j.ijcci.2021.100400
30. Stappers, P. J. (2012). Doing design as a part of doing research. In R. Michel (Ed.), *Design research now* (pp. 81-91). Birkhäuser. https://doi.org/10.1007/978-3-7643-8472-2_6
31. Stolterman, E., & Wiberg, M. (2010). Concept-driven interaction design research. *Human-Computer Interaction, 25*(2), 95-118. https://doi.org/10.1080/07370020903586696

32. Velt, R., Benford, S., & Reeves R. (2020). Translations and boundaries in the gap between HCI theory and design practice. *ACM Transactions on Computer-Human Interaction, 27*(4), Article No. 29. ACM. https://doi.org/10.1145/3386247

33. Zimmerman, J., & Forlizzi, J. (2014). Research through design in HCI. In J. Olson & W. Kellogg (Eds.), *Ways of knowing in HCI* (pp. 167-189). Springer. https://doi.org/10.1007/978-1-4939-0378-8_8