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What makes design research more useful for design professionals? An exploration of the research-practice gap

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Abstract: Academic design research has developed a rich collection of knowledge and tools, but often the results fail to land in design practice. We conducted an interview series with experienced design professionals to study how the knowledge that they derived from research projects was of use to them. They used tools, papers, books, and their own experience in research projects to learn about designing, about the application domain and about project organisation. We found that useful knowledge for design practice can take

various formats, including prescribing tools which serve as demonstrator and a reference frame. We discuss how academic researchers can use these insight to make their research more applicable in a way that meets design practice needs.

Keywords: design research; research outcomes; research impact; research-practice gap; design practice.

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After an education in experimental physics (MSc 1984), Pieter Jan Stappers made the switch to Industrial Design Engineering (IDE) at TU Delft, and followed a research path which led from human perception, spatial imagery, Virtual Reality (PhD in 1992), to design tools and participatory design techniques. As professor of design techniques (as of 2002) he has pursued developing research and education in design techniques for the early phases of design. Core elements in his work are 'research through design', 'experiential prototypes', and participatory techniques such as 'contextmapping'. On each of these subjects he has published both in academic books and journals, and developed education materials for broader impact.

1 Introduction

Design professionals constantly develop their skills and knowledge in many different ways and for different purposes. For instance, a design professional seeks to improve on prototyping skills. Another needs knowledge on a specific topic, such as interface design for mobile apps, as this is a new area they intend to step into. According to Dorst (2008), particularly senior design professionals also seek knowledge that helps them create the conditions for doing design, such as assigning roles in collaborations, and developing ways to deal with a complex field of stakeholders. This paper zooms in on how design professionals benefit from one of the ways to attain new knowledge: by their interaction with research projects.

As all professionals, design professionals learn a lot on the job when carrying out their projects. They also read books, papers, magazines, and blogs, and attend trainings, masterclasses, and workshops. In more mature disciplines such as UX design, a shared language and a selection of methods are available, whereas in a new area such as systemic design much is still unclear. Some design disciplines, such as service design, have strong communities in which knowledge exchange is organised. This enables them to exchange with peers in meetups, network events and conferences. Also, as indicated by for instance Herring et al. (2009) and Mougenot et al. (2008), they collect design artefacts and images from projects by other designers and store these in personal archives for future inspiration.

This study focuses on what design professionals take from one of these sources of knowledge: research projects. They can read the resulting papers or attend conferences and there is a variety of ways to seek collaboration with academic researchers. For one, they can consult the researchers as experts within their own projects, or use them to access otherwise hard-to-reach academic papers behind pay-walls. Also, design professionals sometimes take an active part in funded research projects with academic researchers and other practice partners. They are often asked to join such projects to bring their specific knowledge, skills and expertise, for instance in a role to conduct user research in a specific area or to design research artefacts. Their motivations for joining include wanting to contribute to research and the related societal challenges, but also to deepen their own understanding on certain topics, to explore new fields, and to build up cases. For instance, a design professional specialised in design for healthcare joins a research project about designing for children with cancer. Experienced in dealing with the hospital environment, this professional conducts part of the user research activities in the project and as a result learns more about this specific area of child oncology and its jargon, stakeholders and issues.

The uptake of research outcomes in design practice is subject to some discussion. Research projects by design departments of universities often aim to contribute to social, environmental, economic or cultural issues, as indicated by Rodgers et al. (2020). In many cases, they also contribute useful knowledge for the design discipline, as is often explicitly the aim of grant givers. However, academic discourse and application in practice often seem separate worlds, as described by, e.g., Koskinen et al. (2011). The space that exists between research and professional practice is indicated in multiple disciplines as ‘the research-practice gap’. In the neighbouring field of education Neal et al. (2015) describe this gap as a lack of communication between academic researchers and professionals and as limited implementation of research findings in practice. In the design field, this gap has been acknowledged decades ago (e.g., Butler, 1985). Several

authors (e.g., Dorst, 2008; Rogers, 2004; Stolterman, 2008) have indicated that knowledge from research projects, despite all good intentions, does not land in practice. For instance, Rogers (2004) points out that many methods or models that result from research are not actually used in design practice. Daalhuizen (2014, p.5) offers some underlying reasons for this lack of uptake. Many methods have a non-appealing form (Araujo et al., 1996), are too complicated (Subrahmanian et al., 1997), and lack the vocabulary of designers (Frost, 1999). Dorst (2008) also suggests that the rule-based methods and tools that research often produces are not aligned to the pattern-based way of working of especially experienced design professional. Beck and Ekbia (2018) add that design professionals often lack the time to carry out the detailed analyses that comes with some methods or approaches.

We recognise a growing interest in design practice and several efforts to improve the knowledge outcomes of design research for design practice. Norman (2010a) proposes to follow other disciplines (such as the health sector) and use translational developers to act as intermediary between the different mindsets and interests of academia and practice. Several authors (e.g., Goodman et al., 2011) argue for research *into* design practice to provide a better understanding of design practice. Several studies have taken this approach, for instance studying best practices (e.g., Tempelman et al., 2015; Bongard-Blanchy et al., 2015). Others (e.g., Kou and Gray, 2019) have explicitly studied the topics of interests within design practice in order to provide focus for academic research.

However, little research has been done on what happens when the different worlds of academia and design practice meet in research projects. We indicated that their collaboration is often not a one-way knowledge transfer, as both contribute to knowledge development. But to build an understanding of this collaborate knowledge development, we need to better grasp how design professionals benefit from such collaborations, especially because this benefit of research for practice has become an explicit desired quality in calls of funding organisations.

In this study, we conducted an interview round among design professionals with experience in collaborating with academia and studied how the knowledge from those projects was of use to them. What did design professionals learn from projects in which they had an active role? What did they learn from attending the closing symposium of a project and acquiring the book out of interest for the methods that were used?

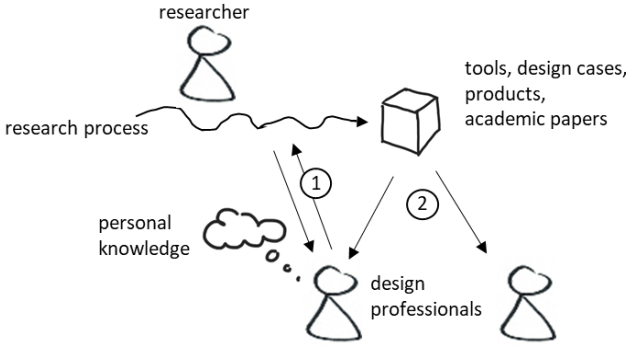
2 Theorising the research-practice gap

Figure 1 depicts our conceptualisation of how knowledge flows between a design research project and design practice. We define the research-practice gap as the difficulties obstructing this flow. At the heart of this figure lies the research process, often a team effort led by an academic researcher, which results in papers, tools or other deliverables. In what ways does the knowledge developed in this process flow to practice? As Kok and Schuit (2012) suggest, a research project has impact through a trail of contributions from the project to the involved actors and to users beyond the project. In this line, Greven and Andriessen (2019) argue that a research project also impacts practice by enabling the involved partners to learn by participating during the process, not only from papers and tools for a larger audience. So the knowledge flow to design practice includes the adoption of tools and methods in design practice (arrows #2 in Figure 1) as well as what design professionals learn by taking part in the research (arrows

#1). Taking part can include taking an active part in research and/or design activities, joining advisory boards, or attending workshops or partner meetings.

The difficulties that can occur in these ways of knowledge flow can be explained using two concepts: personal knowledge and conceptual artefacts. We look at both of these to fully grasp how knowledge production in research projects works, as Bereiter (2002) advocated. The personal learnings of professionals that partake in research projects can be described by what Bereiter calls *personal knowledge*. Some of this personal knowledge is explicit and easily shared with others. But personal knowledge also contains the embodied and experiential knowledge that remains tacit (Polanyi, 1966). Some tacit knowledge can be explicated.

Figure 1 Knowledge can flow from a design research project to design practice in two ways. Design professionals can use conceptual artefacts such as tools, design cases, products, and academic papers (arrows #2) and they can learn by taking part in research (arrows #1). The difficulties obstructing this flow form the research-practice gap



When called upon, some only after deep reflection, and some is difficult to explicate. Nonaka and Takeuchi (1995) provide some ways to transfer parts of such tacit knowledge 'tacit to tacit' by face-to-face sharing and by shared experiences between individuals, for instance by working together in brainstorms or workshops.

Papers and tools are also often described as containers of knowledge, as they convey for instance theory and guidelines. These types of outside-our-heads knowledge are indicated by Bereiter (2002) as *conceptual artefacts.* Dong and Maton (2014) and Löwgren (2013) show how design research projects tend to produce conceptual artefacts on different levels which cover a range of abstractions. Based on this notion, Sleeswijk Visser (2018) describes the range of theory constructs, contextual knowledge, guidelines, concepts and solutions. Gaver (2014) proposes that researchers can convey some of their tacit personal knowledge in shareable conceptual artefacts such as annotated portfolios.

Academic researchers develop conceptual artefacts with various knowledge functions, such as knowledge that describes, explains, or evaluates. To bridge the research-practice gap and to support design practice and design education, they also develop knowledge that *pre*scribes such as guidelines and methods. However, the lack of uptake of methods by design practice has led academic design researchers to discuss this prescriptive function. Stolterman (2008) proposes that designers can be 'prepared-for-action but not guided-in-action' by detailed prescriptions. Daalhuizen (2014) argues that although methods are often not used as the intended prescriptive set of instructions that they are, they do function as mental tools for designers to frame a problem or to provide a

frame of reference when looking back at past activities. Fricke (1999) and Bender and Blessing (2004) found that flexible method usage actually leads to better performance than strictly following methodological guidelines.

Additionally, several authors (e.g., Dorst, 2008; Turnhout et al., 2019) have stressed that design practice also needs explanatory and evaluative knowledge. Dorst (2008) describes academic design researchers as too eager to prescribe and failing to provide explanation. Rogers (2004) shows that design research in the field of HCI is already making the move from mainly offering informative, predictive and prescriptive knowledge towards developing more analytic and generative approaches.

This conceptualisation of the knowledge flow from academic design research to design practice enables us to explore the type of knowledge that design professionals acquire from design research. This paper aims to answer the following research questions:

a How were the knowledge outcomes of design research collaborations of use for experienced design professionals?

b What characterises the usefulness of these knowledge outcomes for design professionals?

We understand 'knowledge outcomes' as both the personal knowledge that they attained in a research process, as well as the conceptual artefacts that resulted from these projects. We considered the format of these conceptual artefacts: e.g., did they come as a report, a template fill-in tool, a card set? And we studied their function: e.g., did they have a describing or prescribing nature?

3 Method

Our study focuses on Dutch design professionals and how funded design research projects in the Netherlands were of use to them. As in many European countries (e.g., Design Council, 2018), design in the Netherlands is growing as a discipline that has both economic impact (Rutten et al., 2019), and a growing scientific credibility (Voûte et al., 2020). In the last 10 years the Dutch creative sector and funding agencies have cooperated to create opportunities for design research collaborations between academic design research and design professionals, providing a relevant context for our research goal. For this explorative study, we conducted qualitative semi-structured interviews with eight design professionals that we acquired by purposive sampling. Table 1 lists the design domain the respondents work in, their position, their design experience in years, and the size of the agencies. In the results we refer to the respondents by the numbers D1 to D8. Four respondents have previously collaborated in projects with the first author, the other four were reached by snowballing from those four. The resulting sample is a varied set of participants that all have a minimum of 10 years of experience as a design professional. All participants work in agencies that are based in the Netherlands, two of which have a worldwide scope. All but D5 have ample experience as partner in research projects and are able to report from their experiences within one to three recent projects. This includes partner roles as co-researcher or designer, or as a member of an advisory board. D5 has prior experience with research in a former employment at a university of

applied science. All respondents could draw from recent experience of using end results of research projects, e.g., by reading a paper, trying out a tool, and attending a seminar.

Table 1 Overview of respondents D1 to D8, listing the design domain they work in, their position, their design experience in years, and an indication of the size of the agencies

	Design domain	*Position*	*Years of experience within design practice*	*Size of agency in number of employees*
D1	Service design	General manager	15	10–15
D2	Product design	Senior industrial design engineer	20	10–15
D3	Service design	Partner/service design consultant	30	10–15
D4	Service design	Head of design	25	>50
D5	Experience design	Self employed	10	1
D6	Service design	Strategy director/design researcher	25	10–15
D7	Service design	Design researcher	10	10–15
D8	Product design	Senior designer/project lead	20	25–30

Three main topics were covered during the interviews: situations of applying knowledge from research projects, the type of involvement of the respondents in these research projects, and the characteristics of the knowledge that they used. Examples of questions are listed in Table 2.

Table 2 The topics and examples of questions in the interviews with eight design professionals

Topics	*Examples of prompting questions*
Use of knowledge	Can you describe a situation in which you were really helped by what you learned from a research project?
	What were you trying to achieve?
	How did this knowledge help you?
Involvement in research projects	Can you tell me about your experience as a partner in this research project?
	What other ways do you use to learn new things?
Characteristics of knowledge (personal knowledge, conceptual artefacts)	What did you learn from this project, and what did it bring?
	Can you describe what you actually used? Did you use the card set, the model, the guidelines etc.?

The manner in which we asked them to elaborate on the situations of applying knowledge was based on the Critical Incident Technique (Flanagan, 1954). We asked the respondents to describe situations in which they were really helped by what they learned from research projects, and asked them what they learned and how this helped them.

The first author conducted all interviews. The duration of the interviews ranged between 1 h and an hour and a half. Three interviews were held face to face, the others were done by telephone. All interviews were audio-recorded and transcribed.

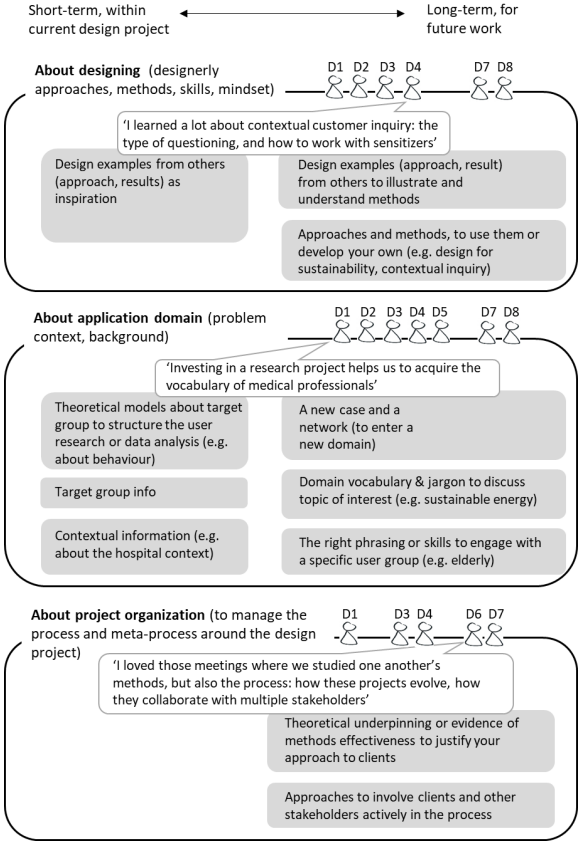
We first coded all interviews using a coding scheme constructed with the previously introduced elements: use (what did the respondents describe to use knowledge for), type of involvement, personal knowledge (what did they personally learn), and format and function of conceptual artefacts. Open and axial coding was then conducted to answer the research questions.

4 Results

4.1 Three content categories

The respondents gave various examples of knowledge that was useful to them. We grouped these into three content categories: knowledge about the design approach, about the application domain, and about project organisation (see Figure 2). Each category is substantialised by examples from a majority of the respondents (respectively six, seven, and five respondents). Some knowledge is used in a short-term context of a specific design project, and other knowledge more on the long run.

Figure 2 Examples of useful knowledge from research projects provided by the interviewed design professionals (respondents D1 to D8). The examples fall in three content categories: knowledge about designing, about the application domain, and about project organisation. Some examples illustrate short-term use, other long-term use



Knowledge about designing is about designerly approaches, methods, mindset and skills. Respondent D4 describes this as mostly learned on the job: "I think that 90% of the service design domain develops during our projects". The respondents hardly look for new knowledge about designing amidst the worries of a design project. Mostly they draw from their own repertoire, or as D7 describes: "I use the expertise of my colleagues". They see learning about new design approaches or techniques as long term professionalising. Eventually, they aim to be able to offer more to their clients, as respondent D8 describes: "We hardly look for new methods. When we do, it is mostly at lectures or masterclasses. I see this as professionalising, not as something I need right now".

Knowledge about the application domain is about the problem context and background. For instance, a model in a scientific paper about the energy transition helped in a specific energy related project to structure and process relevant information. Models are used by the respondents to structure their user research, to set up an interview guide, or to structure the output of the analysis. The respondents also extend their vocabulary or skills in working with a specific user group, as D1 describes: "Investing in a research project like that helped us to acquire the vocabulary of medical professionals". Respondent D4 learned the right phrasing in addressing elderly people in a project. Joining a research project also enables them to build a relevant case and network that help them enter a new domain.

Knowledge about project organisation covers ways to manage the design process and the meta-process around it. Respondent D6 describes: "We work a lot in agile environments where you have to respond quickly, and constantly be in touch with your clients. This is a totally different way of working than a few years ago in terms of process, collaboration, and your role as partner". Several respondents also describe the need to explain and justify their approaches to clients, which is even more complicated in a rapidly changing environment. Respondent D6: "You have to develop new practices". Respondent D7 explains how they more and more need to closely involve clients actively in various steps of the process. Respondent D6 benefited from a research project in which the approaches of several service design agencies were studied: "I loved those meetings where all partners reflected together, studying one another's methods, but also studying the process: how these projects evolve, how they collaborate with multiple stakeholders. Normally, you do not helicopter on this meta-level".

4.2 Active involvement, less-active involvement, and audience

The respondents obtained this useful knowledge by various ways of involvement to research projects, which we grouped in three types: active, less-active, and audience. Each category is substantialised by examples from a majority of the respondents (respectively seven, five, and all).

All but one respondents describe projects in which they were actively involved. They appreciate if they are able to really co-create with academics to contribute to the development of the field, but D3 adds: "There are not many research projects in which design professionals are really part of the intellectual process". Active involvement can produce useful learnings in all three content categories described above. Knowledge about project organisation is exclusively reported as the result of such active involvement.

Involvement in a less active way occurred as taking part in an advisory board or as a consultant (D3), or being involved 'at some strategic moments' (D2). Sometimes they join a project meeting in which a colleague is more actively involved (D2) or discuss with a colleague who is doing the research (D4). "I like to be able to have an influence as creative professional, by giving feedback and by pointing out what is interesting and important for creative professionals" (D3).

All respondents describe examples of using knowledge from projects in which they were not involved. They indicate that they learn from such projects as audience by reading papers or buying the tool.

4.3 Developing personal knowledge

As an active project member, the respondents develop personal knowledge which involves not only explicit understanding but also implicit understanding, intuition and skill. They extend their vocabulary or skills in working with a specific user group, and learn to work with new methods, like respondent D4 indicates: "It has become a standard part of my internalised body of knowledge". Respondent D2 describes that if you conduct research yourself, you get more out of it then when someone else provides you with results: "Participating in a research project works best to make something your own. […] We use these new methods because we feel ownership. And we had some opportunity to work with them and master them". Complex matters, such as designing for behavioural change, are hard to take in just by reading books as respondent D1 states: "If I would have just read the book it would not have sunk in". Respondent D4 adds that to use complex theory, you also have to build up skills. "This is so complex, you really need to conduct multiple projects and build up skills to fully deploy the value of this tool".

Sometimes they pick up things that were not part of the explicit project goals. Respondent D4 describes to have learned more about conducting contextual customer inquiry, which was a means in the project and not an objective: "I learned about the type of questioning and how to use sensitisers to activate people to generate more data.[..] I picked up this methodological knowledge because I was an active member".

Respondent D3 suggests that some personal knowledge is transferred 'tacit to tacit': "I feel that a lot of connections were made between the researchers and the agencies. Apart from the explicit outcomes, the forming of such a community allows knowledge to find its way to practice in a less explicit way".

4.4 The format of conceptual artefacts

Many examples of useful knowledge mentioned by the respondents involve conceptual artefacts such as models, tools or guidelines. When the respondents are not involved in a project this is their primary way of learning from knowledge outcomes of a project. But also when they are actively involved and developed personal knowledge they use these conceptual artefacts in certain ways.

In projects where respondents took an active part they were happy that the research outcomes became tangible and visual in a physical tool such as a card set. They used the tool to explain the results to their colleagues (who were not involved), and to show it to their clients. But they soon stopped using it. Respondent D2 describes this process as follows:

> "I am glad that we did not just put the results on a website but made a tangible card set that you can put on the table. That way it is very visual, making it [the model] easy to explain to clients. […] At first we used the card set to explain things to each other. But it is quite big and contains so much information. And the people who use the theory do not need the card set anymore. They use the five elements that form the core. I think this is because they master it now."

This is in line with the experience of D3: "The card set was used in the beginning, but not after that. It is a way to capture something though and get something across". He adds: "Those methods, tools or fill-in templates often do not fit very well with what you do. But the knowledge on which they are based is often useful". "The tools were tailored for use and incorporated in the respondents" own way of working. Respondent D1 describes how a particular tool was not used, as "the whole design suggested completeness, but if you looked into it, it turned out not to be complete enough for us to dare to use it in projects. But I did not mind that we did not use these instruments in the end, because we developed other instruments that we do use". The agency developed their own way of working, based on the same theory. "It does not work to just give us a finished tool. We will change it anyway". Several respondents describe how they prefer a tool that accommodates them to make their own version. D7 describes: "I really like researchers to come up with a version that is not quite finished. So that we can contribute as designers, from the perspective of applying this, to look at the model and theory again and see how we can improve it".

When the respondents were less actively involved in a project they were often not in the position to develop actionable outcomes themselves within the project. But they describe how –from this position – they sometimes urged researchers to make conceptual artefacts more actionable and manageable. For instance, the persona method (Grudin and Pruitt, 2002) is mentioned several times as a way to capture knowledge about a target group in a manageable and actionable way (D2 en D8). Respondent D8 said: "If they would have given us these personas of elderly people. That would have helped us to create better products for the future".

The respondents stress the importance of studying design cases conducted by other design professionals: "Exploring and strengthening my profession is also about experiencing, studying and discussing the work of others". (D5). Not only the solutions are studied, but also – especially – the approach that others used: "How did they translate the model to results? What obstacles did they encounter, what have they tried?" (D7). And very important, what kind of result comes out, as respondent D8 describes: "That is the first thing I look for: how can it lead to a new interesting perspective and to a different result". As respondent D1 said: "I don't think that academic researchers realise that inspiration is so important in these projects".

To learn from projects in which they are not involved, the respondents engage with the conceptual artefacts via books and scientific papers. Visually oriented designers tend to search for figures, graphs, and models. However, D5 points out that scientific papers are more difficult to come by as they are often behind a paywall. Personal contacts with academic researchers are used to provide access to these papers (D1), or they directly involve researchers and their knowledge in their work (D2, D8). Respondent D8 notes that taking the time to learn something new, beyond the scope of your current project, is often done away from the daily troubles of projects: "While working on a project, you do not stop to think of learning something new. So learning something new takes place at

other moments, away from the office. In the train, in the evening, in the weekend, at a lecture or a training day".

4.5 Knowledge functions

Prescriptive knowledge, such as guidelines or methods, is not used in the prescribed way. For instance, respondent D1 used a method for giga-mapping and found out that they should have taken the guidelines with regard to the required size more serious: "We realised in our evaluation: oh yes, we really should have paid attention to this. We thought: two by two [metres] is also big. But it turned out it wasn't big enough!" She explains that this relates to how they use prescriptive knowledge such as guidelines: "We don't use it as a guideline. We use it more as a suggestion: you might do it like this.[…] You don't have to understand all the finer points, that will follow in practice".

The knowledge function intended by the researchers does not always match the actual function in practice. Indeed, the respondents are often not aware of an intended knowledge function. Respondent D7 describes the use of a card set, but used the main elements of the model to map the assumptions of the client about their target group behaviour in five categories. She adds: "Was this type of use intended? Actually, I do not know. Before, I used a different model, but I prefer this one".

The respondents also use explanatory and evaluative knowledge, like respondent D3 who wants to understand how peoples' behaviour can be influenced. However, respondents D1, D2 en D5 report a difference in what researchers consider a well-grounded result vs. what they find useful themselves, as D2 adds: "I understand that you want to substantiate everything from a researchers" perspective, but to help us you could make things clearer and easier to apply (D2). Respondent D1 states: "In practice, it matters whether we are able to work with it". It also helps if explanatory or evaluating knowledge is supported by visual models or an illustrative tool. As D1 describes: "It really worked for me to see how you could translate a scientific theory like that to instruments that you can use". Respondent D1 indicates that her colleagues, who conduct most of the actual design work, needless explanatory background than she does: "They just want to use a tool and do not need all the theory. I am involved in business development, in showing others that we really know what we are doing. They just have to show that we are doing it really well".

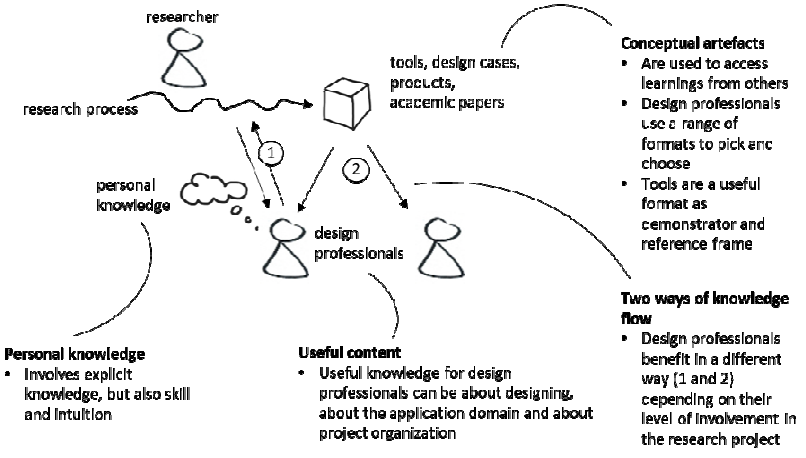
5 Discussion and practice implications

5.1 Discussion

Figure 3 presents our main results in relation to the earlier presented conceptualisation of the knowledge flow to design practice (Figure 1). We discuss the results and conclude this section with practice implications.

The content that design professionals found to be useful ('useful content' in Figure 3) can be distinguished in three categories. They report to learn about designing (designerly approaches, methods, mindset and skills), about the application domain (problem context and background) and about project organisation (ways to manage the design process and the meta-process around it).

Figure 3 Main results: how knowledge outcomes from design research collaborations are of use for experienced design professionals, and what characterises this knowledge as useful



These categories resemble those indicated by Dorst (2008). He proposes that design research should also focus on the meta-activities of design professionals, such as how they put together a design team or negotiate a contract, not just on design processes and on the content of design problems. Kou and Gray (2019) point at a similar 'beyond the cubicle' category as topic of interest in online Q&A activities in the UX domain. Our results reflect this interest for knowledge about meta-activities, and what is more: they indicate that research projects can contribute in this.

The results illustrate how design professionals benefit differently from a project depending on their level of involvement to it. As an active member, design professionals learn things they cannot take from papers or books. They acquire personal knowledge such as experiences, deeper understanding of design methods, improved design skills, and extended domain vocabulary. As non-involved audience, they rely on the models, methods, tools and examples which Bereiter (2002) calls conceptual artefacts. As a less active member, e.g., by joining a workshop, they benefit by elements of both ways. They acquire some personal knowledge during their interaction with the research process. However, they also use output such as personas or other tools to be informed from activities in which they were not involved. As the involvement of design professionals in funded research projects is often limited due to funding restrictions, this combination will often be the case.

These two ways of knowledge flow, personal knowledge and conceptual artefacts, play a different role for each of the three content categories. Design cognition literature stresses the importance of personal knowledge when it comes to knowledge about designing, e.g., describing how especially experienced design professionals rely on intuition (e.g., Cross, 2004; Dorst and Lawson, 2009). In line with that, our respondents describe how methods or models need to be internalised and become part of the professionals' own repertoire before they are used. This might be the reason why it is hard for respondents to recall how certain personal knowledge was acquired and to trace the source. In what way did a research project contribute to their personal knowledge about designing? How did a method in a paper contribute to this? As respondent D5 describes: "Sometimes I have internalised things so much that I do not recall what it was

I read or heard". They might learn things on a very tacit level without being aware of it. This would make it harder for researchers to recognise and acknowledge these tacit learnings of the design professionals. It might also make it hard to share these learnings to inform the collaborative knowledge development process. Sleeswijk Visser (2018) reports that generated knowledge is not always captured and shared effectively among research actors. She proposes an explicit structuring of roles to safeguard both the capturing and the sharing.

The respondents talked most easily about what they learned about the application domain and how they used this knowledge in practice. It could be that this type of knowledge is very top-of-mind for design professionals amidst the everyday troubles of a design project. Dorst (2008) indicated that design research displays a growing interest for the content of design problems. However, the results also suggest that this type of knowledge does not always make it to output that can be shared with other design professionals (e.g., conceptual artefacts such as personas), as this is often of less interest for other research partners such as domain professionals.

The respondents link their interest in knowledge about project organisation to their role in a complex and rapidly changing environment. In this, we recognise the complex environment described by Norman (2010b) and the collaborating and orchestrating role that design professionals need to take according to, e.g., Sleeswijk Visser (2018). This third type of knowledge, about project organisation, is only mentioned by design professionals who design services. Perhaps because service solutions often consist of people, relations and organisations as 'materials' of the solutions, requiring design professionals to "really take clients on the path of change" (respondent D4). We also note that the respondents apparently learned about this type of knowledge from their own experiences in a research project or those of other practice partners in similar projects. This suggests that this type of knowledge can typically be elicited *from* the experience of practice, especially in a relatively young and developing field which has had less opportunity to consolidate its ways of working. It might be that the relevance of this type of knowledge about meta-processes is not recognised by both researchers and design professionals, as suggested by Dorst (2008), nor the way that it is developed. It is often not part of the stated research purpose or even the motivation for the design professional to join the project, but apparently proves to be of value to them along the way.

Conceptual artefacts are the primary means to deal with knowledge outcomes of a project for design professionals who were not involved. But they are also used by design professionals who were more or less actively involved in the project themselves. They use pieces of knowledge that describe or prescribe, such as models, guidelines, and methods, but also that explain or evaluate. Some prefer more background or theory than others, depending on their professional role or personal interest. These findings underline the call for explanatory and evaluative knowledge (e.g., Rogers, 2004; Turnhout et al., 2019) as well as illustrate the value of informative, predictive and prescriptive knowledge. Also, in line with studies into design practice (e.g., Herring et al., 2009), the respondents stressed the importance of using examples such as solutions and design cases. The results indicate that design professionals prefer a combination of the above in a range of formats, in which for instance a theory is supported by a visual model and demonstrated in a design case.

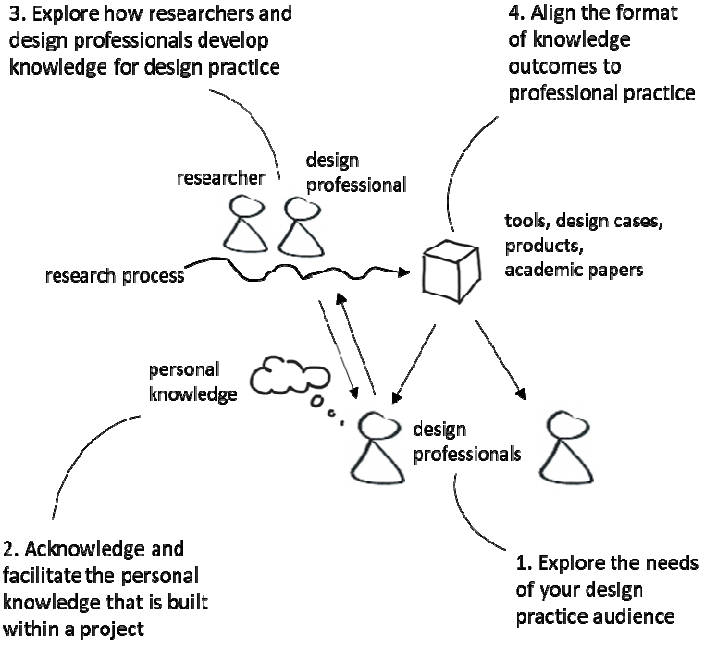
In line with the earlier presented literature, our results also indicate that prescriptive tools are not used as prescribed. Once design professionals sufficiently understand the idea behind a tool, they will hardly use it at all. However, a prescriptive tool still seems a

recognisable format that works for design professionals. It has a value as a demonstrator: a visual and tangible tool to share the underlying ideas with others, such as clients or co-workers. Moreover: design professionals use such tools as inspiration for their own versions. This corresponds to how Daalhuizen (2014) proposes that design methods serve as 'mental tools': as inspiration and reference frame. It seems that a method card set resonates with design professionals in a similar way that a products does, by tapping into one of the designerly ways of knowing that Cross (2001) indicates: gaining knowledge by interacting with and reflecting upon the use of an artefact. They read it like a chef reads someone else's recipe as inspiration for his own dishes (but will definitely not make the same recipe).

5.2 Practice implications and future research

These findings suggest several practical implications and opportunities for future research. We propose four ways that may help academic researchers to make the knowledge outcomes of their research projects more useful for design practice (Figure 4).

Figure 4 Four suggestions for academic researchers to make the knowledge outcomes of their projects more useful for design professionals and bridge the research-practice gap



First, consider the design practice audience of your research project and use the three content categories to explore their needs. What motivated your design practice partners to join your project? And what do they find useful along the way? Do they want to get acquainted to a certain method, or to learn about a specific application domain? And how can other design professionals also benefit from your project?

Second, acknowledge and facilitate the personal knowledge that is built within a project. Some of this might be shared with others beyond the project, e.g., explicated in conceptual artefacts, or conveyed in training and workshops. Consider if you can facilitate more opportunity for learning and building skills, as D4 suggests: "just let people learn along the way, so that they internalise it in a different way than by reading a book or listening to a trainer".

Third, apply this understanding of useful knowledge for design practice in order to explore how researchers and design professionals develop these different types of content within in a project.

And finally, align the format of knowledge outcomes to professional design practice. Aim for a tool that demonstrates the use of the research findings, rather than a practice-ready tool. Provide design professionals with the range of forms that they seem to prefer. In the chef's analogy, this range of forms includes not only other chef's recipes, but also their dishes, the science behind certain baking processes, the account of their experiences, their ideas and their failures.

These guidelines provide several opportunities for future research that are not limited to the Dutch research landscape, but have a more general appeal. Our next study is directed at the ways in which design professionals are considered and served as target group within design research (1), and the way in which knowledge that is relevant for design practice is co-created with design practice partners (3).

6 Conclusion

We set out to investigate how knowledge outcomes from design research collaborations are of use for experienced design professionals and what characterises this knowledge as useful. We studied this by interviewing experienced design professionals who have participated in state sponsored research collaborations.

Design professionals use tools, papers and books, but also learn from their own experiences in research projects. They learn about designing, about the application domain and about project organisation. Useful knowledge for design practice can take various formats, including prescribing tools which serve as demonstrator and reference frame, not as a recipe.

We suggest four ways for academic researchers to make their project more useful for design practice: explore the needs of your design practice audience, explore how researchers and design professionals develop these different types of content, pay attention to the personal knowledge that is built within a project, and align the format of knowledge outcomes to professional design practice.

The contribution of this paper lies in the focus on the design professionals' perspective on the collaborations of academic researchers and design practice. We confined this study to Dutch design professionals and what they took out of state sponsored projects. Although the scope of this study is limited and localised, we believe that the results are of interest for a broader international community of academic researchers and design professionals who want their collaborate research projects to impact design practice.

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