An Analysis and Critique of *Research through Design:* towards a formalization of a research approach

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ABSTRACT
The field of HCI is experiencing a growing interest in Research through Design (RtD), a research approach that employs methods and processes from design practice as a legitimate method of inquiry. We are interested in expanding and formalizing this research approach, and understanding how knowledge, or theory, is generated from this type of design research. We conducted interviews with 12 leading HCI design researchers, asking them about design research, design theory, and RtD specifically. They were easily able to identify different types of design research and design theory from contemporary and historical design research efforts, and believed that RtD might be one of the most important contributions of design researchers to the larger research community. We further examined three historical RtD projects that were repeatedly mentioned in the interviews, and performed a critique of current RtD practices within the HCI research and interaction design communities. While our critique summarizes the problems, it also shows possible directions for further developments and refinements of the approach.

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Design, research through design, design research, design theory

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H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
The field of Human-Computer Interaction (HCI) is experiencing a growing interest in the use of *research through design* (RtD); a research approach that employs methods and processes from design practice as a legitimate method of inquiry. One reason for this is that the HCI research community has moved beyond a focus on usability and is increasingly engaging in research on "Wicked Problems," (for example, societal problems such as sustainability) which cannot be easily reduced. RtD lends itself to addressing these problems through its holistic approach of integrating knowledge and theories from across many disciplines, and its iterative approach to reframing the problematic situation and the preferred state as the desired outcome of the research.

As design researchers within HCI, the overall goal of our work is to expand and formalize the use of RtD as a research method, and to better understand and document *knowledge that is generated* from this type of design research. We believe that RtD offers several distinct advantages to the HCI community. RtD allows researchers to rely on designerly activities as a way of approaching messy situations with unclear or even conflicting agendas; situations that are not well suited to other methods of inquiry. Additionally, RtD forces researchers to focus on research of the future, instead of on the present or the past. Finally, RtD provides an opportunity for the research community to engage in discourse on what the preferred state might be as an intentional outcome of the research, allowing us to consider the ethics of what we design. This focus on the future and the focus on concretely defining a preferred state allows researchers to become more active and intentional constructors of the world they desire.

While examples of RtD within the HCI community continue to grow, we acknowledge that there are legitimate challenges in further formalizing this type of research. Since RtD is an inquiry process revolving around the making of a product, service, environment, or system, the knowledge gained can be implicit; residing almost entirely within the resulting artifact. Additionally, RtD is not a formalized approach. The research community has yet to develop criteria for specifying appropriate approaches and for evaluating the quality of contributions. Finally, there is no agreed upon method to document the knowledge — methods, theories, and insights — that emerge from this type of research.

In this paper, we take a step towards formalizing RtD as a legitimate method of inquiry within the HCI research community by detailing how RtD can lead to *design theory*. In our focus on theory how RtD can produce theory as a research outcome, we engaged in several activities. We conducted a literature review related to knowledge and theory both within and beyond the design and HCI communities. We conducted interviews with 12 leading HCI design researchers, asking them to characterize general examples of design research, specific examples of Research

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through Design, and examples of design theory as outcomes of design research. After synthesizing these interviews, we examined three historical RtD projects that were repeatedly mentioned in the interviews, mapping how they produced theoretical contributions. Finally, we performed a critique of current RtD practices within the HCI research and interaction design communities; discussing how the outcomes of RtD can be more complementary to other types of HCI research contributions. While our critique summarizes the problems, it also shows possible directions for further developments and refinements of the approach.

RELATED WORK

As mentioned above, RtD is an emerging and unrefined research approach in HCI. It is also an approach not commonly associated with theory development. Therefore we find it necessary to establish some common ground through a literature review where we focus on three aspects relevant for our purpose. We provide a background on RtD, a brief overview of what "theory" is, and a brief overview of how theory has historically been described in HCI.

Research through Design (RtD) Background

There have been many characterizations of design research (see [14] for an overview); and many of these characterizations point to Research through Design as a canonical type of design research activity. Many researchers view RtD as a designerly inquiry focused on the making of an artifact with the intended goal of societal change [1, 36, 45]. The design community has extensively discussed what RtD is, how it should be practiced, and what it should produce. The focus on intended outcome links RtD to Simon's definition of design in *Sciences of the Artificial* as seeking a preferred state [34].

Some in the design research community view RtD as design science [1], while others consider designerly thinking as distinctly separate from scientific thinking [30, 45, 35]. In an attempt to distinguish RtD as separate from science, Zimmerman et al [45], link RtD with Rittel's concept of "Wicked Problems" [31, 3] that are by definition not approachable using scientific or engineering modes of inquiry. In both cases, researchers acknowledge that the goal of solving a wicked problem is a solution that is optimal for the current situation and not a focus on the discovery of truth [1, 45].

Based both on the approach and the focus on societal change, a connection can be made between RtD and the Action Research approach used in the humanities and the social sciences [25, 36]. The action research sequence of iteratively planning, acting, observing, and then reflecting makes the inquiry approach nearly identical, and both approaches involve interdisciplinary teams [36], or at least the integration of knowledge from several disciplines [45]. Koskinen even claims that design researchers appropriated action research as an underlying model for RtD [25].

Other researchers view RtD as a broader practice than making artifacts with the intention to create societal change. These researchers see RtD as a way of broadening the scope and focus of designers, of challenging current perceptions on the role and form of technology. Instead of trying to transition the world into a particular preferred state, these researchers instead want to advance the practice of design with the goal not only of creating societal change but improving society at large [17]. No matter how the end goal is described, all design researchers agree that RtD is about research *on the future* [18, 25, 36, 1, 45].

Many critiques of the current practice of RtD can be found in the literature. Some note that most examples of RtD are poorly documented [25]; and that some design researchers feel an artifact should stand for itself, without the need for textual support [36]. Some design researchers claim RtD should always be done both with a "theoretical scaffolding" so as to distinguish RtD from design practice, and that it should be conducted within a research program that focuses the inquiry across several cases so that the results work to support or challenge commonly held assumptions [25]. Finally, researchers attempting to distinguish RtD from design practice note that the process of RtD allows design researchers to ignore commercial concerns in order to focus on new understandings of technology [18].

RtD is also seen to generate several different outcomes. Many researchers see design methods as a natural outcome of RtD. In their view, these methods allow designers and design researchers to consistently apply the theoretical model underlying the method [1, 25]. However, some believe that in the HCI community, methods are often appropriated without respect for and deep knowledge of the underlying methodology [25, 2]. Other researchers see RtD as producing design theory that is distinctly different than scientific theory, in that it is a theory of action followed by meaning instead of meaning followed by action [30]. The resulting artifact can be seen as a *proposition* for a preferred state [36, 45] or as a *placeholder* that opens a new space for design, allowing other designers to make artifacts that then better define the relevant phenomena in the new space [18]. Finally, design researchers have claimed that RtD can result in conceptual frameworks and guiding philosophies [46] as well as community discourse on preferred states, identification of gaps in current theories from other disciplines, and indications of new materials (technology) that would be especially valuable to invent [45].

While RtD has become a somewhat common approach in the design research community and is becoming more recognized in the HCI community, details of what constitute this approach have not been well discussed by either community. Today it remains much more as an attitude to doing work than a systematic method of inquiry. If design researchers expect others to recognize the rigor and relevance of this approach, then they must engage in a critical discourse to better detail what this method entails and what its outcomes might be.

Theory

In its simplest form, a theory describes the structure and relationships between phenomena [16]. Theories can also take the form of taxonomies that organize related elements, or descriptions of more dynamic situations that include processes and actions. A theory often attempts to provide a simple, high-level view while providing detail about the underlying complexity.

In an attempt to unite quantitative and qualitative methods of inquiry, Edmondson and MacManus proposed a theoretical continuum running from nascent, to intermediate, to mature [9]. Nascent theory generally emerges from more exploratory work (generally qualitative), where the important relationships between phenomena are unknown and therefore difficult to focus on. Nascent theory often works as a proposition of a new area that needs more of a discovery approach in order to surface what the important relationships between phenomena might be. Theory matures through discourse as researchers confirm, refute, refine, and extend the work of others, moving to quantitative approaches. Scientific theory is mature theory that emerges from repeated observation. As the artificial world continues to change, mature theory is challenged and the need for nascent theory that proposes new sets of relationships is continually required.

Theory development or theorizing can take the form of anything from describing relationships between constructs early on in a research problem to testing mature and well-established relationships. The development of new theories has been described as "the development of propositions" or "disciplined imagination, where the researcher defines, conducts, and interprets imaginary experiments" [28, 40 p. 516]. What we argue in this paper is that RtD has so far contributed theory of the first kind — nascent theory development that makes propositions about important relationships between phenomena. In addition, in RtD, we see a need for intentional theoretical development where the establishment of overarching theories becomes accepted as an outcome for HCI researchers taking this approach. For this to happen we believe the field needs a more developed sense of theory and a more formalized RtD approach.

Theory in HCI

Historically in HCI, theory has been inspired by many of its constituent disciplines. Some researchers have described HCI theories as psychological theories of human behavior [4]; as engineering theory intended to improve HCI practice [26], and as anthropological theories of situated action and interaction [6]. Others have noted that HCI research often involves the holistic construction of artifacts, and like in design research, theory in HCI research can also reside implicitly within a resulting artifact [4]. They also note that it is difficult, if not impossible, to control the many relationships between variables when making artifacts, making traditional scientific approaches challenging [4]. Finally, they note that the practice community often invents new and better approaches and then theory arises to confirm the hunches of designers [5]. Examples of this include the theory of direct manipulation, which did not emerge until twenty years after direct manipulation interfaces began to appear. As additional disciplines such as anthropology and design have had influence on HCI, theories from these disciplines have been introduced, critiqued, incorporated, and accepted. This is now the case for design theory within HCI.

INTERVIEWS

The overall goal of our interviews was to understand (1) if and how design research has reached a stage of acceptance in the HCI community, and (2) if theory can be recognized as a formidable outcome from design research. We used discoveries from our literature review to guide and structure a set of interviews with key design researchers in the field of HCI. In our interviews, we searched for commonly mentioned examples of design research, for evidence of successful RtD projects, and for *theoretical contributions* developed from the results of design research efforts.

We conducted qualitative interviews with 12 leading design researchers currently working in the field of HCI and interaction design research. Four had PhDs in computer science, two in informatics, two in architecture, two in psychology, one in philosophy, one in sociology, and one in design (note two possessed dual-PhDs). Seven held the position of full professor, one as a research professor, three as associate professor, and one as an adjunct professor. In addition, two directed research centers, two were department heads, and one was a dean. Five held faculty appointments in schools of design, three in schools of arts, two in information schools, and one in a computer science department. Six came from North America, five from Europe, and one from Oceania. Ten participants were male and two were female.

We chose a focus on interaction design and HCI because these communities engage in interdisciplinary work that integrates behavioral science, engineering, design and other disciplinary perspectives. Research contributions must connect with a design research audience, a scientific research audience, and an engineering research audience. We wanted to speak to an audience that was sensitized to interdisciplinary tensions. These conversational interviews specifically asked participants to describe design research, describe and provide examples of design theory, describe and providing examples of RtD, and speculate on the problems and challenges of RtD within the interaction design and HCI research communities.

FINDINGS

In the interviews, participants were easily able to identify several types of design research that could lead to theory, providing evidence that design research is alive and well in the HCI community. A majority of our participants also identified instances of design theory from contemporary and historical design research efforts.

Design research

Participants spoke readily about their views on design research, and made classifications of different types of design research. Interestingly, most responses followed Frayling's three characterizations of design research: research about design, research for design, and research through design [15].

Research about the design process (Research about Design) was the most commonly mentioned type of design research. This activity focuses on understanding the human activity of design. Participants mentioned examples from designers, philosophers, rhetoricians, and social scientists, among others.

Interviewees also spoke of research focused on improving design practice (Research for Design). Outcomes of this activity included frameworks, philosophies, design recommendations, design methods, and design implications. Participants mentioned that these outcomes generally help designers reframe the problems they are addressing. Many of these rely on knowledge established in other disciplines, for examples, knowledge about human experience that comes from philosophy or cognitive science. Many of these constructs are a logical jumping off point for providing design theory.

A third type of design research activity that was mentioned was the process of iteratively designing artifacts as a creative way of investigating what a potential future might be (Research through Design). This approach to design research was seen as exciting and rewarding, because it allows designers to do what they do naturally (to design), and to create a stepping-stone to theory generation.

How design research produces theory

After Frayling's characterizations of design research, and building on the examples cited in our interviews, we characterized two types of design theory: *theory on design* and *theory for design*. In addition, we characterized *research through design* (RtD) as an *approach* that can lead to *theory for design*, and possibly to *theory on design*.

Theory on design grows naturally from research on the design process, creating knowledge about how and why people design. The goal of this type of theory is to move towards a unified understanding of the human activity of design, rather than to provide theories that help practitioners improve the practice of design. In our interviews many participants mentioned Donald Schön's work on reflective practice [32]. A few also mentioned Löwgren and Stolterman's *Thoughtful Interaction Design*, noting how it characterizes the designer during the activity of design [27].

Theory for design is theory that is developed with the intention of improving the practice of design. This kind of theory takes several forms: conceptual frameworks, which often take the form of applying knowledge from the human science disciplines and applying it to design; guiding philosophies, which take the form of sensitizing concepts to help direct designers and researchers in solving design problems; implications for design that result from inquiry into wicked problems; and design implications arising from the analysis of designed artifacts, for example, in the research on interaction design pattern languages.

Some of the examples of theory for design that were mentioned in the interviews include the many frameworks of experience and co-experience which emerged about ten years ago as the HCI community became interested in user experience with products (see [13] for an overview). Other frameworks that participants mentioned took the form of sensitizing concepts for design, for example in the work of the Product Ecology [12], a framework which helps designers to understand the context of use of a product; Designing for the Self [44], a framework that explores supporting individual ideals as a means for design; and rich interaction design [7, 30], a framework that describes how designers can consider the full range of human sensory inputs as a means for aesthetic design.

Participants also talked about theory on design in terms of guiding philosophies. Like the frameworks, these are also intended to help designers by offering ways to reframe design problems, thereby broadening the scope of design activity. Participants mentioned work on tangible interaction, particularly Ishii's work on the glass bottles [22, 23], and they mentioned the work on design for appropriation, a guiding philosophy about products that are designed without an intended use, allowing users to invent their own meanings and uses [33].

Design implications, generally found at the end of many HCI papers, were another type of theory for design participants mentioned. For example, research on different demographics and different contexts of product use can create sets of design implications intended to inform the design of new products and services or to suggest changes to the design of current systems. Participants mentioned the PARC research on how people use email to manage personal information [42], design patterns that resulted from observations of everyday creative practices [39], and Taylor and Swan's "Artful Systems in the Home" [37]. The latter two research efforts explore daily family activities and how to design for them.

Finally, participants mentioned theory for design that results from an analysis of artifacts to reveal underlying relationships. Tufte's work on graphic and information design principles was mentioned as a well-known theory for design contribution of this type [38].

Research through Design

Almost all of the participants were familiar with RtD, and the examples mentioned cast RtD as an *approach* to doing research that could lead to *theory for design*. Participants noted several forms of theory that result from RtD, such as conceptual frameworks and guiding philosophies. In addition, they mentioned that RtD can result in new

research and design methods that allow users to more effectively apply the theories they have produced. Finally, participants described how RtD lead to new artifacts (products, environments, services, and systems) where the artifact is itself is a type of implicit, theoretical contribution. The power of these artifacts was described in how they codify the designers' understanding of the current state, including the relationships between the various phenomena at play therein, and the description of the preferred state as an outcome of the artifact's construction.

When asked to provide canonical examples of RtD, participants mentioned many different projects, perhaps not in terms of outcome, but instead in terms of characteristics of each project that made them ripe for knowledge development. These included the Maypole Project [20], the Equator project [10], and the Quality Interaction Group's research at Technical University Eindhoven [7, 30]. Some of these characteristics included the fact that these were longer-term research projects, often funded by large European initiatives that allowed for repeated investigations of an issue; that these projects were influenced by theories outside of design (for example, the Quality Interactions work was first inspired by theories of visual and spatial perception); and that these projects attacked wicked problems, compromised of many overlapping areas of context.

Several participants also mentioned Ishii's glass bottles as an example of RtD, describing how conceiving of technology as a material allowed for a creative and inspirational rethinking of what interactive products might be [22]. They noted the power of this example to inspire, but noted that the research project did not seem driven by a theory or to have theory as an intentional outcome. In fact, one participant, while claiming to love this example claimed it failed to guide other researchers on specifically how to add to this research space.

One participant also talked about the architect Frank Lloyd Wright's development of the Usonian home plan as an example of RtD, describing how building the homes helped to generate and refine the design principles. This example helps to illustrate that RtD is not a new concept, but perhaps a natural part of design practice. It also hints at the need to more clearly define how RtD fits into both research and practice.

One participant mentioned that RtD, as an approach to research, might be the single most important contribution of design researchers to the larger research community. He noted that the first challenge for a design researcher taking on an RtD project is to verify that the problematic situation is indeed a "Wicked Problem" that requires a design inquiry approach, and not simply a complex problem that can more effectively be addressed through scientific or engineering methods of inquiry.

When the characteristics of a project are good, and repeated RtD investigations can take place, knowledge in the form of design theory can result. However, it was acknowledged this kind of outcome is often realized later, after a period of reflection on the problem framings that were chosen, the methods that were evolved and employed, and the artifacts that were created. Critical to the process is the recording of methods that were employed and steps in the design process, but in a community that has only recently embraced publishing work in peer-reviewed conferences and journals, this is sometimes an afterthought. These issues formed not only the basis for discussions about theory in RtD, but the issues for improvements and standardizations that formed the basis for a critique of the current state of design research.

Figure 1. One RtD outcome from the Maypole Project was a prototype that suggested the future of MMS messaging (originally published in [20]).

HISTORIC EXAMPLES

A number of historical examples were cited repeatedly in our interviews as canonical examples of design research and design theory production. Many blend aspects of Research for Design and Research through Design. We examined three of these projects — Maypole, the Equator project, and the work of the Designing Quality in Interaction group — to more closely understand how knowledge was produced as an outcome of this work.

Maypole

Maypole was a two-year European research project funded by i3net, the European Network for Intelligent Information Interfaces [20]. The goal of the project was to develop communication concepts for children aged 8-12 and others in their social networks.

The project employed a multi-phase design process, including user studies, participatory design stories, and other activities that were very forward-thinking for the time. As such, the interplay of design and research

Figure 2. The Drift Table, one of of the RtD outcomes from the Understanding Interaction themes of the Equator project. Photo credit: Interaction Research Studio (originally published in [10]).

Figure 3. The Emotional Alarm Clock, a seminal product concept from the Designing Quality in Interaction group at TU/e (originally published in [7]).

processes was published as an early exemplary type of design research.

The prototype they created offers an excellent example of knowledge generated from RtD. Mobile technology to do what designers envisioned did not exist at that time, so researchers cobbled together a camera and output screen, tethered together and carried in a backpack. A number of these prototypes were built and used in a field trial, allowing participants to experiment, make and share pictures and videos, and talk about how they might communicate with mobile messaging.

Knowledge generated from this work included new interaction design paradigms from the prototype shown in Figure 1, and new research methods based on participatory design that explored acting out social interaction and concept evaluation, either in a staged or real world context [20]. The entire project itself offered a user-centered design process that is still being adopted and extended in the design and HCI communities, as team members recognized that traditional usability studies were not sufficient to evaluate concepts that described future states [24]. Additionally, Maypole members critiqued their design and knowledge generation process, offering actionable information for other RtD efforts [24].

Equator

Equator was a 6-year project funded by the Engineering and Physical Sciences Research Council in the UK [10]. The project spanned multiple disciplines and groups, and was divided into three challenge areas: Devices, Infrastructure, and Understanding Interaction. The Devices challenge focused on devices that would interleave digital and physical interaction. The Infrastructure challenge focused on the infrastructure needed to support holistic configuration of these devices with the goal of supporting user experience. The Understanding Interaction challenge focused on outlining concepts and principles to support interweaving physical and digital devices, and the methods needed to design and evaluate these systems. This challenge contained many RtD efforts, and allowed researchers to explore future ideas through conceptual, forward-thinking work, focused on several themes including playing and learning, the curious home, the city, and games, among others.

The knowledge generated from the numerous efforts in the Equator project took many forms. First, the prototypes themselves were experiments with material and technology, codifications of understanding about users and contexts, and sketches of potential futures. Second, many principles and concepts were developed to support building technology and to consider the user experience that might result. Finally, a set of user-centered research methods evolved to help others develop these forward thinking products. For example, the Drift table was an artifact developed during the project that offered a proposition about how to use technology, a prototype that people responded to in their homes, and the basis for design theories formed around the sensitizing concept of Ludic design (Figure 2) [19].

Designing Quality in Interaction

Technical University Eindhoven is the site of the research of the Designing Quality in Interaction group. The work began in the 1990s with the overarching goal of taking inspiration from objects in the physical world and engaging all of the human senses in designing interactions with digital technology. Research was inspired by theories from the psychology and philosophy of perception, including J.J. Gibson's work on affordances of the perceived environment. Repeated research investigations have been made under this effort, resulting in what group leader Kees Overbeeke, in a 2009 plenary lecture called "a new design

process, a new educational approach and a new approach to research".

Some of the contributions of this work include artifacts that were designed as explorations of what might be, such as an alarm clock that inferred the emotional state of the user, based on how the alarm was set each evening (Figure 3), and a digital camera that relies on rich physical interaction to make and edit images, rather than a series of pushbuttons [7, 41]. Other theoretical contributions took the form of frameworks and guidelines to shape interaction design to support physical interaction and engage the senses [41], and the sensitizing concepts of *feedforward* and *inherent feedback* in designing digital interfaces for products. These efforts, over time, helped to better articulate the research framing of the group, cast the seeds for future research, and create many ways of communicating research ideas, ranging from art exhibits to scholarly publications.

The work of Maypole, the Equator project, and the Designing Quality in Interaction group creates fertile ground for the development of knowledge in the form of design theory. All of the projects employed a Research through Design approach, creating artifacts that included products, prototypes and models that illustrated future visions, uses of new materials, and potential ideas. All of the projects generated guidelines and sensitizing frameworks to provide the design research community with information about how to design. Finally, aspects of all projects were documented, ranging from methods and design processes to work that generated scholarly publications with the goal of multidisciplinary outreach. Interestingly, all of these projects were centered in Europe or the Nordic countries, where design as an academic and scholarly activity seems to have more legitimacy and more stable funding than it does in the United States.

A CRITIQUE OF RTD

While most of our interviewees were quite optimistic about the possibility for RtD to continue to develop, they did mention many obstacles for this particular approach that prohibits it from enjoying the status of a well-defined research paradigm. These included a still-present romantic view of design, the implicit nature of design theory to come from the making of things, and administrative difficulties with doing this kind of work both in academic and industrial settings.

Many participants mentioned that RtD and designers conducting research in general suffer from a romantic view of design. This was explained as an understanding of design as a process that is not "rational", "logical", "transparent" and "rigorous" in a traditional scientific sense. These complaints echo the views expressed by design practitioners who work with researchers and mediate design practice activities with other research activities [43]. However, the view of the *genius designer* is more destructive when held by researchers, because it seems to say there is not a place for design inquiry to make a systematic, rigorous, and relevant research contribution. A romantic understanding of design will therefore hinder the development of RtD into a research approach that has its own logic and rigor that complements and advances research from the sciences.

Participants also mentioned that as currently practiced, knowledge production, especially in the form of theory, never seems to be an *intended* outcome at the start of a RtD project. Instead, it was either implicit and remained implicit after a project concluded, or it only emerged from reflection after the fact. Some participants argued that "good" RtD usually does lead to theory development even though it might not have been the original intention of the research group. Participants called for a more explicit ambition to develop theory, which could be articulated at the beginning of the design research effort.

In their discussion of theory and formalizing this approach, a number of participants focused on documentation of the design process. They claimed that in order for RtD to intentionally create theory, the community needs to form standards for documenting a RtD process. They claimed that researchers would need to describe how their problem framing and their perception of a preferred state changed over time and document the findings that triggered these changes.

The other main challenge participants mentioned was the lack of examples and critical analysis of these examples for this kind of research. They noted two distinct challenges for creating more and better examples. First, the community needs more venues where these types of research contributions can be published. Second, the funding agencies that support research must provide more funding to support this approach to research.

Call to action

Based on our literature review, interviews with design researchers, and our own experiences from conducting RtD, we formulated an overall critique of RtD as compared with more recognized and established research approaches. While this is a critique of the present state of RtD, it can also be read as a list of actions that need to be taken to develop RtD into a valid and recognized research approach. The major challenges include successful methodology development, research examples, theory critique, and evaluation criteria.

Methodology development

We argue that there is a need for serious development of RtD into a proper research methodology that can produce relevant and rigorous theory. In our interviews, participants asked for more rigorous documentation of progress and evolution of RtD projects. Such documentation should preferably cover the whole process from problem framing and the idealized preferred state to the final outcome. In addition, specific attention would be paid to detailing how theories from other disciplines were integrated in the process and how the resulting artifact helps to refine or

challenge the general theory through reflection on its application.

Like any other research approach, RtD must develop protocols, descriptions, and guidelines for its processes, procedures, and activities. It is also critical that RtD as an approach becomes more explicit about its purpose and about the kinds of problems it can best address over other methods of inquiry. Similar to the points made by Edmondson and McManus in describing how qualitative and quantitative research can feed each other, design researchers must better rationalize why a RtD approach is the right approach for the problem they face instead of using it simply because they are familiar with it.

Finally, from the interviews it was clearly stated that there is a need for a developed understanding and sense of what constitutes high quality outcomes and measures of success, that is, how can and should RtD projects be evaluated and how can theoretical contributions from this research be critiqued and valued. Design researchers need to both reach an agreement among themselves and to engage those who take more scientific approaches into this discussion so that the contributions are recognized and appreciated by the larger research community.

Research examples

A need exists for more examples where the *intentional* choice and use of the RtD approach as a methodology and process is both described and critically examined. The examples are important since they makes it possible for different researchers and groups within and ancillary to the design community to examine each other's work and test out each other's theories by extending, copying, or testing individual efforts. However, this is not done with the expectation that results from prior efforts would be exactly replicated, as in the sciences. Instead RtD has to find its own ways of approaching traditional research qualities such as reliability, repeatability, and validity through ways that are trustworthy while true to the approach.

Additionally, RtD today is seldom conducted with a declared intention of creating and building theory. This means that theory development is in many cases more of an afterthought than an intentional outcome. Theorizing in its different forms is a delicate process that has to be well developed, described, and understood in order to lead to trustworthy results. The interviewees saw this as a weakness in today's RtD approaches and asked for example research projects were theory development is the core purpose of the research.

Theory critique

Researchers who engage in RtD need to pay more attention to the work of other design researchers. As in any mature field of research, there is a need for *critical analysis of theoretical outcomes* through serious theoretical analysis and criticism. Serious critique of theoretical propositions is the first step towards any kind of theoretical synthesis. Building knowledge and theory can only be done by both adding to and challenging other researchers' work. The field is still dominated by a sense that "being first" and that creating something "new" is more valuable, recognized, and sought after than in-depth analysis and critique of existing theoretical proposals. It is possible with the RtD approach to repeat research done by someone else, to design research that could challenge other researchers' results, etc. Theoretical critique is necessary for the field to build any form of synthesis and to establish foundational theoretical propositions.

A broader theoretical project is not achieved only by reports of findings in the form of traditional research papers. Theoretical discourse is mainly done in the form of the essay, which is currently not recognized and accepted as a valued publication in the field. Our interviewees noted that RtD is a form of research that is suitable for the essay format but that there are not enough places suited for manifesto papers, forward thinking papers, conceptual propositions, and other theoretical investigations since they are not usually accepted in the field's scientific publication venues. Creating opportunities for theory critique and discourse can bring together theoretical results from many studies into more ambitious theoretical constructs.

RtD has the intrinsic ability of bringing many ideas together through the process of composition and integration which are core activities in a designerly approach. This means that RtD is not only suitable for the early steps in theorizing — the formation of nascent theory — but it also supports the development of more comprehensive and mature theoretical constructs. However, it is obvious that such more ambitious and intentional theoretical projects are in need of a well-developed process and precedents. In making this connection to Edmondson and MacManus' theoretical continuum of nascent to mature, we wish to be clear that we are not advocating a science of design. Instead, we are proposing that RtD can be a designerly way to produce nascent theory. This nascent theory is different and more designerly than the nascent theory produced by qualitative fieldwork in that it focuses on uncovering important relationships between phenomena in the near and speculative future and not in the present.

Overall, based on the interviews, we are confident that RtD can develop into a recognized and established research approach. It is not an approach that has to start from nothing. Our interviewees testified that they knew about existing and earlier RtD efforts that have shown good results and that have created theory. However, these results are still not necessarily recognized as contributions resulting from the same research.

It is of the utmost importance that RtD is analyzed and critiqued in a serious and ambitious way. Based on our study we are confident that RtD is here to stay and severe critique is at this stage not detrimental to the approach. It is therefore more important that researchers who are involved and who advocate for this approach become the most

"aggressive" critics of the approach. Constructive critique of the approach is the only way to make the approach robust and stable over time. It is also the way a research approach becomes accepted and recognized.

CONCLUSION

Design research is alive and well, and our interviews showed that different types of design research are uniformly recognized by the design and HCI communities. Design research, and specifically RtD, is beginning to produce theory that can be applied to many types of design, and to have an effect on other types of research.

While the work presented in this paper shows that established researchers in the field can indentify both projects that have been conducted as RtD and theoretical contributions from this form of research approach, there is still a lot to be done when it comes to establishing RtD as a recognized and well-developed research approach. To that end, we have established a critique of RTD that summarizes these issues and shows possible directions for further developments of this approach.

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