Lessons Learned from Research through Design

An empirical research towards practical guidelines for Research through Design

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ABSTRACT

Research through Design entails the generation of research insights by performing a design exercise. In literature, Research through Design has not quite taken shape as a methodology that supports its practical use. Therefore, literature provides little practical guidance to conduct a research led by this approach. To fill this knowledge gap, this article identifies three lessons learned that can serve as practical guidelines to support a Research through Design led research. These lessons learned are formulated based on the analysis of a research project on five methodological aspects of Research through Design which are found in literature. Further research can be conducted by applying these lessons learned to future researches and test their supportive contribution to the progress of the research.

Keywords

Research through Design, Methodological aspects, Guidelines, Conceptual Design Process

1. INTRODUCTION

Research through Design (RtD) is described in literature as an approach for scientific inquiry, taking advantage of the unique insights gained through design practice. The approach thereby provides a better understanding of complex and future-oriented issues [1]. This design practice comprises the efforts to structurally and continuously design and refine an envisioned artefact [2]. RtD is a conceptualising research done by means of the skillful practice of design activity, revealing research insights [3]. More specifically, this knowledge is gained by conducting a design exercise and continuously reflecting on direct and indirect observations, beliefs and experiences. The approach has a highly iterative character, switching frequently between a theoretical and a practical perspective [3].

Since the concept of RtD was coined by Frayling in 1993 [4], several definitions of RtD have been introduced in literature [1, 3, 5]. RtD is still debated and discussed since "*no agreed upon research model existed for [...] designers to make research contributions other than the development and evaluation of new design methods*" [5]. The approach does not (yet) entail practical guidelines for researchers to hold on to. Furthermore, some characteristics of RtD are contradicting classical research. For example, in classical research, "drifting", i.e. the capricious way research can progress, is considered as erroneous because of the fact that the grounds and measures of its evaluations are in constant motion [6]. However, in design this same "drifting" is used as a quality measure. When elaborately documented, it tells the story of the designer learning from experience and adjusting the course of action. Besides, some scholars state that RtD is in the business of knowledge, not of design [7], however, others do not share this opinion [8].

Although its presence in literature, RtD has not quite taken shape as a methodology that supports its practical use. Literature provides little practical guidance to conduct a research led by this approach. Some research on RtD is focused on the development of a corresponding methodology [3, 8]. However, such research is mostly conducted through theoretical reasoning. Some researchers analysed RtD-led research to strengthen its formal definition [9], to develop insights about the role of the design artefact in RtD [10], or to extend knowledge about one methodological aspect of RtD [6].

Practical-oriented research can substantiate the knowledge base of the RtD approach regarding its methodological aspects. This study aims to formulate guidelines to support the use of RtD, thereby enhancing the rigour of the RtD approach within its scientific body, such that RtD can be conducted more effectively. It addresses the methodological aspects of RtD, defined by Creswell [11] as the "process of research". This article provides three lessons learned for the practical use of RtD as a research approach, based on the analysis of a RtD-led research that serves as case study; a master thesis project on the conceptual design of Artificial Intelligence-driven solutions for the optimisation of business processes.

First, a brief literature review of the methodological aspects of RtD will be presented in Section 2. Next, a description of the case study will be provided in Section 3. Subsequently, Section 4 analyses the case study by reflecting on its development utilising the methodological aspects of in Section 2, serving as an umbrella to structure this analysis. The insights gained will thereafter be synthesised in Section 5 to formulate three lessons learned. Section 6 concludes this article and presents directions for future research to develop and refine the methodological aspects of the RtD approach.

2. METHODOLOGICAL ASPECTS

In order to analyse the development of the case study, methodological aspects of RtD have to be found. Therefore, a literature review is conducted to identify these methodological

aspects. Literature is found through a search via multiple sources of scientific literature on RtD, namely *Google Scholar*, *Scopus* and *Web of Science*.

RtD is related to methodologies such as grounded theory and action research, but is also different. Jonas [8] states that grounded theory "aims at theory building, while accepting the modification of its subject matter". Meanwhile, action research aims to "modify reality, while observing and processing theoretical modifications" [8]. RtD can identify itself to some extent with these definitions and would position itself in between these two descriptions. That is, it entails both the modification of reality and theory, performing a design exercise to embody these modifications. Hence, RtD is sensitive to drift. From this comparison of RtD with related methodological approaches, we can assume that RtD has some methodological aspects. To find and denote these aspects, a literature review on RtD conducted by Godin & Zehedi [1] is used as a starting point.

To summarise, the following methodological aspects of RtD are extracted from the literature review conducted: What *type of design project* the research is, the *interaction moments and types* with other people relevant to the research, How the *documentation* is done during the research and the reflection on the process of progress, which consists of the *development of the designed artefact* and the *generation of research relevant insights* from this development. On these methodological aspects can be reflected in a RtD-led research. These five methodological aspects of RtD are described in the rest of this section.

Type of Design Project

First, the type of design project executed in the research is considered to be a methodological aspect. That is, because design projects exist in many forms and their role in RtD-led research is prominent. The type of design project determines the design shapes, and thereby also the research outcomes. Thereby, the design phase (or phases) that the design project addresses is (are) important, since it determines what the outcomes of the design exercise will be [2]. For example, an Architectural Design exercise produces a different product than Logical- or Physical Design efforts.

Moments of Interaction

A second important process-oriented aspect of RtD is the way interaction with other people relevant to the research takes place. As RtD-led studies are often conducted with and/or through other people, it is important to notice in hindsight the way this interaction took place and at what moment in time in the research period. One can think of stakeholders relevant to the designed artefact and collaborators of the research itself. This is because these people affect the design process and thereby the research itself. For the reproducibility of the study, the researcher therefore ought to describe these interactions.

Documentation

While conducting an RtD-led research, the design evolves over time. One of the main concerns regarding the methodology of any RtD-led research resides in a "more rigorous documentation of progress and evolution of RtD projects" [3]. Thus, the documentation of the process of the RtD research is of importance. This includes both the documentation of the evolution of the design artefact itself, and the documentation of the development of research insights through the design exercise.

Development of Artefact

On itself, the development of the design artefact in the research is a process aspect of RtD too. In a design exercise, the artefact under design changes. This development of the artefact forms the foundation of the insights the RtD effort produces. Therefore, the way this design artefact changes, and what drives these changes, characterises a RtD project. For this, one can think of grand design choices based on design requirements, design constraints and/or design objectives can be reflected on in a RtD-led research.

Generation of Insights

As mentioned in Section 1, the methodological aspects of an approach entail the knowledge that is needed to establish how a researcher/designer will gather the necessary data in his or her research, to extract its insights/knowledge from. Thus, another methodological aspect can be defined as the process or dynamics of the development of the research insights, to ultimately achieve the research objective. A breakdown of a research process results in several stages of research: the collection of data, the analysis of data and the synthesis into insights [11].

Krogh [6] studied ten PhD theses and identified several 'ways of drifting' of a RtD, i.e., the possibilities for the RtD process to develop. Expanding a theory on the role of experimentation of [9], he drafted a typology of five distinct methods of knowledge production through design experimentation: Accumulative, Comparative, Serial, Expansive and Probing [6]. Figure 1 visualises these five ways an RtD-led research can progress through experimentation. One or more forms can be found in a RtD, as it is possible to switch between different experimental methods. That is, they are not mutually exclusive [12]. As this typology describes different ways the process in a specific research can progress, it can serve as guidance when describing the process of a RtD-led study, denoting some methodological rigour.

To conclude this Section, five methodological aspects of RtD are found. These aspects are used in the analysis of the case study in Section 4.

3. CASE STUDY DESCRIPTION

To conduct this research, a RtD-led research is studied as a case study. This case study is a master thesis project with the research objective '*to strengthen the scientific understanding of knowledge-intensive business process of which its cognition is enhanced by integrating artificial intelligence-driven software, and support their practical development*' [13]. The problem that is challenged in the research is the fact that little shared understanding exists on the design of artificial intelligence-driven solutions for business processes. The research aims to generate insights that can support the development of such software systems.

During the whole research period, a total of four different design artefacts are worked on of which the first three failed to achieve the research objective above and there-

Method	Graphic model	Keywords
Accumulative		Depth, stacking
Comparative		Acknowledging complexity
Serial		Systematising local knowledge
Expansive		Broadening, extending
Probing		Illogical, artistic, impact oriented

Figure 1: Ways of drifting in RtD, adopted from [6]

fore abandoned after some time. The fourth design artefact achieves this research question, which is a conceptual design process. The corresponding research question is therefore worded as follows: '*Can a conceptual design process of knowledge-intensive business processes be created, such that the cognition utilised in the process can be enhanced by integrating Artificial Intelligence software?*'. The research delivered a version of such a particular conceptual design process which consists of six components. Four of these components are sub-design processes: a requirement eliciting process, a capabilities formulating process, a matching process and a design alternatives generating and selecting process. The first three sub-design processes use theories on Cognitive Systems and Design as their theoretical foundation. The two other components of the conceptual design process are a design process coordination component and a component responsible for assessing the availability and quality of data present in the business process under review. The research used two case studies as objects of study. These case studied both comprised of the design and development of an artificial intelligence-driven software solution for claim-assessment processes of health insurance companies.

In order to describe the development of the RtD process of this case study, a visualisation is drafted and presented in Figure 2. The figure shows the different design artefacts the researcher worked on during the research and when (top part of left axis). Furthermore, it shows the theories studied (centre part left axis) and design experiments performed (bottom part left axis) and the moments in time it contributed to the design artefact(s). Since the figure shows which theories and design experiments contributed to the design and thereby towards achieving the research objective, it is thus related to the methodological aspects *Development of Artefact* and *Generation of Insights*. In Section 4, Figure 2 is used to analyse these two methodological aspects of RtD of this case study.

4. ANALYSIS

This section describes the analysis of the case study as described in Section 3 by means of the methodological aspects of RtD found in Section 2.

Type of Design

The type of design that is constructed is a single artefact, the conceptual design process. However, it consists of multiple smaller components, of which four are design processes on themselves. It is a non-tangible artefact. The conceptual design process is contributing to the solution of a wicked problem [14], since the problem does not have a definite or exhaustive formulation: there does not exist one grand conceptual design process.

Moments of Interaction

Throughout the research period, there were multiple interactions with multiple people relevant to the research. The research was conducted for a small-sized company which designs and develops artificial intelligence-driven solutions for organisations. Therefore, during the whole research period, the researcher interacted with experts on such technology-driven business solutions in both formal an informal, structured and unstructured settings. These interactions have led to observations regarding the (conceptual) design of these solutions. Furthermore, the research received valuable feedback from scientists who studied artificial intelligence and system design, both content-wise and process-wise. Besides, the research conducted two case studies at two health-insurance companies. Interaction took place with stakeholders in the claim-assessment process of these organisations, from the developers of the new software system to the people working in such particular business process.

Documentation

The documentation of the case study is the master thesis in which the research is described and can be found in [13]. The documentation of the research comprises of a working document that presents the content of the research, which is iteratively re-written in the research period. In this documentation, different versions of the envisioned conceptual design process are present, which reflect the development of the design process of that artefact. Furthermore, a log of the ways the research 'drifted' is updated throughout the research period and present in the documentation, which reflect the theories and design experiments considered in the research. At last, the thesis itself presents the generated insights from the RtD exercise.

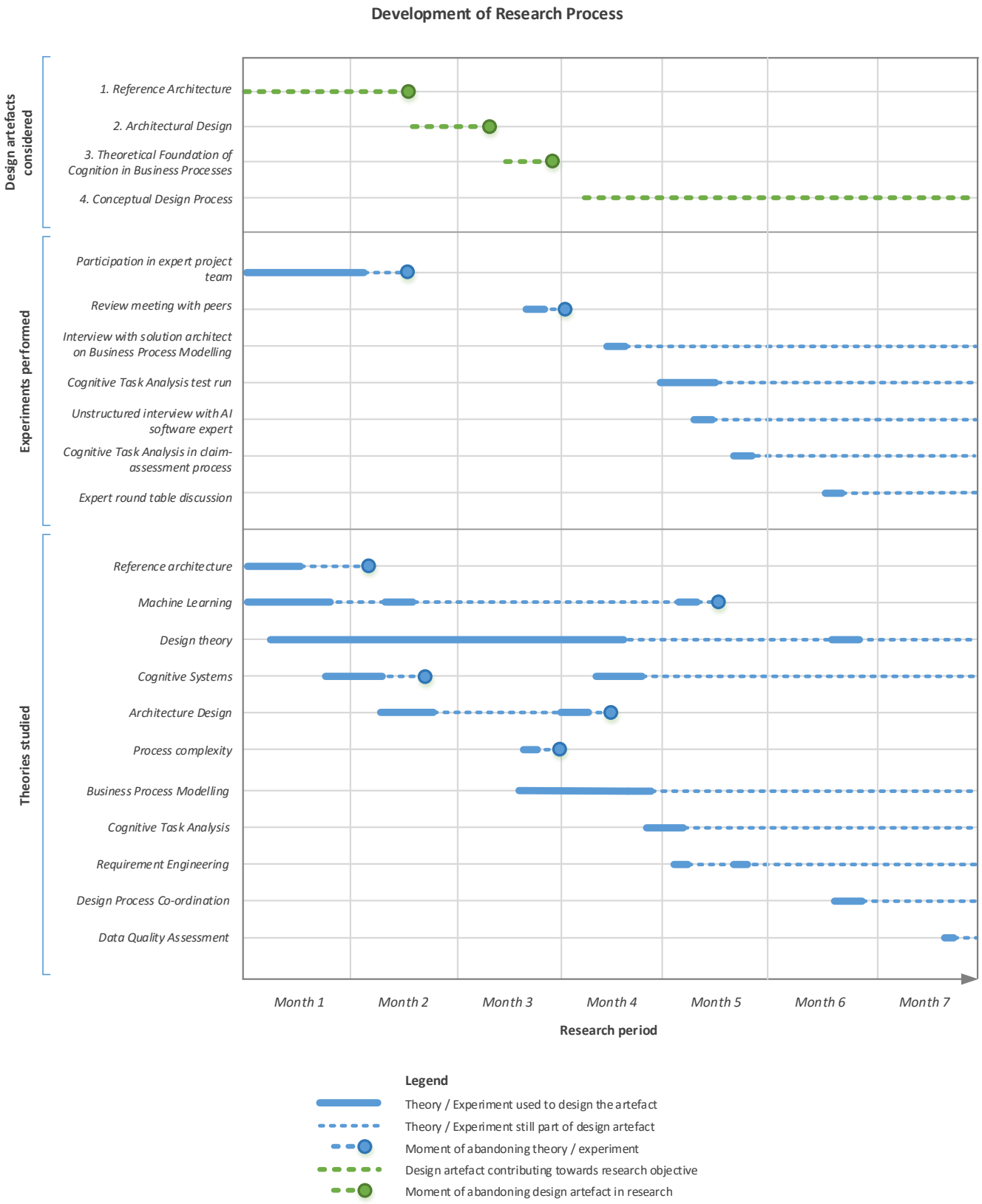

Figure 2: The Research through Design-process of the case study schematically visualised, from [13]

Development of Artefact

Reflecting on the development of the research, roughly two phases can be identified. Briefly, these two phases developed as follows. In the first phase (from month 1 till month 3), the research aimed to achieve the research objective by designing a reference architecture of artificial intelligence-driven solutions in a business process (see Figure 2). However, this proved to be too big a challenge, since architectures of such solutions did not yet exist. Continuing on this, it appeared later that the construction of such architectures was not evident for systems architects. At this moment in the research, the researcher supposed that an Architectural Design itself would create valuable insights to achieve the research objective. However, it appeared that this was also not feasible to design. Later, a theoretical framework was envisioned that could support the creation of such architectures. However, this design artefact later appeared to not achieve the research objective. At last, it turned out that the detailed design was not the major unknown in the whole design process of a solution, nor the preliminary design stage. Namely, the researcher observed that the conceptual design phase was often skipped or just briefly touched upon. More rigorous guidelines for this conceptual design seemed to be desirable. Therefore, the research drifted to creating a conceptual design process especially for these type of technical solutions.

The second half of the research therefore comprised of constructing such a conceptual design process for the particular type of systems. This conceptual design process is built bottom up, making use of design theory for its structure and Cognitive Systems theory for the rationale behind its content. Figure 2 schematically visualises this development process. The design steps described in each design process' component are described in [13]. The process of designing these components can be characterised by experimentation in the case study, analysis of theory and interviews with relevant stakeholders: people working in the business process, people working with AI software, people designing AI solutions for business processes, et cetera. The theories and experiments mentioned in Figure 2 are all used as input in the design process of the artefact.

Generation of Insights

As indicated above, the research had a quite long run-up determining what the eventual artefact should be that had to be designed. This is caused by the type of problem what is addressed: a wicked problem. The first phase of the research proved to be the most important, however also the most challenging. Inherently to a wicked problem, only a rather small part from selected perspectives can be studied. Thus, this phase resulted in the definition of the problem, which theories it can leverage to analyse the problem, working towards a main research question. Note that this phase both utilised theory and practice (design of an artefact) to come to these outcomes. The design exercise makes the problem explicit, it scopes the problem such that it can be researched. It thus had a Comparative and Probing character.

The progress of the second phase can be characterised as an iterative process that continuously revised the design artefact to better fit the problem. Besides that this phase created a lot of insights of design steps and design activities this conceptual design process would consist of, it generated also more general insights regarding the design and development of these types of solutions. These extra generated insights tend to have a more practical relevance than scientific, since these insights where not the main subject of study. This phase in which the conceptual design phase is constructed can be characterised as Accumulative and Serial, since the process constructed the content of the conceptual design process of its phases more or less one by one.

To summarise this analysis of the case study, the research experienced a slow start, searching for a research scope and research problem that would be of value to study and executable within the set time period. Moments of interaction with stakeholders proved to be useful to make progress, as it actively stimulated development. Documentation of the research progress helped to structure the development, as it forced the researcher to explicate his considerations why a certain design choice or theory is good or bad. With hindsight, generating insights whether certain design choices and theories are valuable for the research faster would have sped up the whole process.

5. SYNTHESIS

The analysis of the methodological aspects of the case study provides insights how RtD contributed to the development of the research. Based on the synthesis of the analysis described in the previous section, three lessons learned can be formulated. Mainly the aspects reflecting the way the research progressed have brought up these lessons.

Never waste a good theory or experiment

The first lesson learned is to reconsider abandoned theories and performed design experiments when treading a new result-path. If the design artefact is not creating any progress towards achieving the research goal, the exercise of designing that artefact should be stopped. The research starts designing a new artefact, thereby treading a new result-path of the research. However, previously abandoned theories and performed design experiments can be of value in this new result-path and should therefore be analysed again by the researcher. If the researcher neglects these previously abandoned theories and performed design experiments in the new result path, it can be that potential valuable theories and/or performed design experiments are unseen.

To illustrate this first lesson learned, we take the case study analysed in Section 4 as an example. In during the first stage of the research, the theory Cognitive Systems is analysed and considered of use for the creation of a reference architecture (design artefact 1). After some time, the theory turned out to be not valuable anymore do to changes in the design. However, after two other design artefacts (2 and 3) were considered but abandoned, the research started on designing a conceptual design process (design artefact 4). By coincidence, the researcher stumbled upon the Cognitive Systems theory once again, which turned out to be useful again and fit the design, such that it would achieve the research objective. One can see this re-appearance of the theory to the substance of the conceptual design process in Figure 2.

Monitor when it is time to switch
In a RtD process, the researcher switches between analysing theory and practice to develop a design artefact, thereby gaining research insights. When the researcher studies a particular theory or performs an experiment in practice, but does not progress towards achieving the research objective, and the researcher did not yet reach this research objective, the RtD way of thinking suggests to switch away from this particular theory or experiment. Otherwise, the researcher would put a lot of unnecessary effort in this theory or experiment. Knowing when it is time to switch in the process is therefore valuable, and depends on the amount of effort and chances of success that the theory or experiment leads towards achieving the research objective. Therefore, monitoring when it is time to switch is thus suggested

When the researcher has still a lot of possible valuable paths to tread, and the chances of success of each path is rather unknown, it makes not a lot of sense to put much effort into each of these existing paths. In this situation, it is therefore suggested to not put a lot of effort in each existing path. This results in a part of the RtD process with more frequent switching. On the contrary, when the research already progressed for some time, more information about the chances of success of each path is considered to be known to the researcher. Then, the researcher has only a couple of possible valuable paths left to tread of which the researcher knows to be valuable or not. In this situation, the research can put more effort into analysing the paths that the researcher perceives have a higher chance of success. This results in a part of the RtD process in which less frequent switching occurs. One can see that the ratio between the chances of success and the degree of effort remains constant. To extent on this, researchers who can accurately estimate these chances of success are thus able to better judge when it is time to switch, and when it is not.

In the case study, the researcher spend a significant amount of time on the first design artefact (Reference Architecture). After some time, this design artefact proved to be not useful for the research. During this stage of the research, the researcher considered – amongst other theories – theory on reference architectures for quite some time, as can bee seen in Figure 2. With hindsight, it would have been more valuable to the research to switch earlier to another theory and/or to an experiment, since the theory did not lead to anymore progress while the research objective was still not achieved. Furthermore, in this early stage of the research still a lot of possible paths existed to tread. The researcher did not (yet) monitor and recognise that, at that moment, it would be better to switch. In the end, switching to other theories and experiments resulted here to the design of a new artefact (an Architectural Design). Monitoring when it is time to switch is thus valuable when conducting RtD.

Know what switch to make
The previous lesson learned states that when the research analyses a particular theory (design experiment) too long without any progress along the result-path, the theory (design experiment) is considered to be not of any (more) value. In this situation a switch is suggested. For the researcher to know what switch is best to make is valuable, since switching to a theory or experiment that does lead to progress does not make sense. Four possibilities of switching exist: from theory to theory (1), from theory to practice (2), from practice to theory (3) and from practice to practice (4).

If the researcher is currently studying a theory and the perceived distance towards achieving the research objective is not getting smaller, but the theory is not perceived useless, the researcher decide to switch to an experiment in practice or to an other theory. If the researcher sees opportunities to run an experiment to test the theory in practice, a switch to practice is suggested. Otherwise, a switch to an other theory is found most valuable. If the researcher is currently performing an experiment and the perceived distance towards achieving the research objective is not getting smaller, and the experiment is not going to achieve the research objective, the researcher decide to switch to an experiment in practice or to another theory. If the researcher sees opportunities to run an other experiment to test the theory in practice, the researcher should switch to this other experiment. Otherwise, a switch to an other theory is found most valuable. One can note the underlying preference towards experimenting in practice, due to the fact that such experiments in practice can indicate if a certain design choice increases the chance of success.

The following example from the case study can illustrate this third lesson learned. For the design of the conceptual design process (fourth design artefact), the researcher had the impression that theory of Cognitive Task Analysis could be valuable for the design artefact when studying this theory. At that moment, switching to practice to experiment with this theory resulted in the insight that this theory would be of value to the design and fits too, thereby contributing towards achieving the research objective. Switching to another theory would be a bad move, since the researcher would leave a possible valuable theory. With hindsight, switching from theory to practice is considered here as a good choice.

6. CONCLUSION & FUTURE RESEARCH
An attempt has been made to capture the methodological aspects of the RtD approach by conducting a literature review. The identification of these methodological aspects contributes to the further formalisation of the RtD approach. By analysis of these methodological aspects in a case study, lessons learned are formulated for the execution of RtD-led research. These lessons learned can be used in future RtD-led researches to support its process, as they provide stricter guidance. Thereby, they can be a prelude to practical guidelines of the scientific body of RtD. Furthermore, the lessons learned increase the reproducibility of RtD research, something desired by scholars to properly validate their RtD efforts.

Since the lessons learned are derived from an analysis of one case study comprising of one research, this study can be improved by scrutinising the methodological aspects of other researches led by the RtD approach. That is, more studies like this one can be conducted and see if these also result in similar lessons learned. This would increase the validity of the lessons learned formulated here, and contribute towards their specification into practical guidelines. Next, the usefulness of the lessons learned derived in this study can be assessed by utilising these lessons learned in practice, ap-

plying them in conducting a RtD-led research. By analysing and assessing their supportive contribution to the research's progress, suggestions for improvement of the lessons learned can be formulated. Furthermore, this research is not able to formulate pointers what increases the judgement quality of the researcher what theory or experiment has a high chance of contributing towards achieving the research objective and should be treated next. The experience of the researcher with conducting RtD and his/her knowledge about the subject area seems to affect this judgement quality, as observed by the authors in the case study. Namely, while the research progressed, the time spend on the design artefacts decreased until the fourth and last design artefact was found. Simultaneously, the researcher gained experience with the RtD approach, and his knowledge about the research subject did increase, potentially increasing its judgement quality when to switch. This could be the reason why the time spend on the second and third design artefact decreased relative to the first one. Future research can study this judgement quality more extensively. The last suggestion for future research is identify to formulate more lessons learned, executing similar studies as this one and research other RtD-led researches. In combination with more knowledge on the methodological aspects of RtD, the set of lessons learned present in literature can be a prelude to a methodological framework of RtD.

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