Tradeoffs in Design Research: Development Oriented Triangulation

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The Development Oriented Triangulation (DOT) framework in this paper can spark and focus the debate about mixed-method approaches in HCI. The framework can be used to classify HCI methods, create mixed-method designs, and to align research activities in multidisciplinary projects. The framework is generic enough to capture the diversity of research within the HCI community, while being specific enough to foster constructive debate about combinatorial opportunities and difficulties in mixed-method research in HCI. An analysis of 10 previously published academic HCI research papers showed the utility of the framework for describing a wide range of HCI papers and for raising methodological questions about mixed method approaches in HCI.

Triangulation, Mixed-Method Research, Methodology

1. INTRODUCTION

HCI has been an interdisciplinary field from the beginning (Grudin 2005), although the number of contributing disciplines has grown substantially in the last two decades (Carroll 2003). While most HCI researchers appreciate this diversity, they also hold different views about methods and standards for good research. This makes evaluating each other's work (Bartneck, Rauterberg 2007, Harrison, Tatar & Sengers 2007) as well as cooperating in teams (Mackay, Fayard 1997)challenging.

There are roughly two types of responses to these challenges. In the demarcation response, authors typically offer a classification of the research paradigms of HCI (such as 'design', 'engineering' and 'science') and try to explicate the type of contributions, underlying epistemological assumptions and knowledge standards of these different research paradigms. The underlying idea seems to be to gain understanding for one particular approach (often 'design') as opposed to others (see, for example: Bartneck, Rauterberg, 2007, Harrison, Tatar & Sengers 2007, Jarvis, Cameron & Boucher 2012, Wolf et al. 2006). This response, however, puts the focus on the differences between HCIresearchers and not on the nuts and bolts of multidisciplinary cooperation or the way in which 'interdisciplinarity' as an asset of HCI-research could be appraised.

Another response to the challenges of diversity is the *triangulation* response which recommends

combining methods and, more broadly, epistemological practices from different disciplines (Mackay, Fayard 1997, Petter, Gallivan 2004). This view has been put forward most forcefully in (Mackay, Fayard 1997). Although their views were received sympathetically, their work didn't launch a lively debate about specific triangulation approaches in the HCI literature. This is a pity: since not all combinations of methods or approaches are equally effective or informative, researchers need a language to discuss and share best practices in mixed-method approaches. This situation in HCI is reminiscent of that in the social sciences, where triangulation has been recommended since the nineteen-seventies (Denzin 1970) but where attempts to develop best practice frameworks for mixed method approaches are much more recent (Bergman 2008).

In this paper we try to take a first step to advance the debate on mixed method approaches in HCI. Much like (Bergman 2008) we feel we need a synthesis of the demarcation literature and the triangulation literature to move on. The Development Oriented Triangulation (DOT) framework, which we present in this paper, offers such a synthesis. This paper is organized as follows. First the framework and the way it builds on previous work is presented. After that we show its applicability on 10 recent HCI papers and we share insights resulting from this analysis. We close the paper with a critical assessment of the framework and suggestions for future work.

2. DEVELOPMENT ORIENTED TRIANGULATION

2.1 Two domains for HCI research

In the Development Oriented Triangulation (DOT) framework we cast HCI research as an organized learning activity which is instrumental to an innovation or development challenge and, as such, brokers between the domain of available work and the application domain. The application domain is both object of study and a target for HCI researchers. When HCI researchers develop new software for a hospital they may study work practices in the hospital and they will try to improve it by creating the software. With the domain of available work we refer to the body of existing artifacts, theories and models which researchers can have access to. The HCI researchers of the hospital study will try to learn form available theories and existing solutions for related problems. They will typically strive to make their work available to the HCI community, in turn. This distinction between these two domains is congruent with the views of (Mackay, Fayard 1997) and closely follows (Hevner et al. 2004).

2.2 Overview of the DOT framework

The complete DOT-framework is shown in figure 1: it identifies five types of research, which are organized along 3 central trade-offs which HCI researchers face when they select research methods. In the following section each of these trade-offs is discussed in turn.

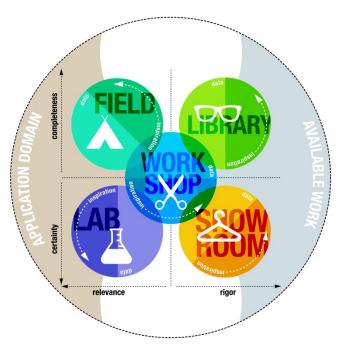


Figure 1: The development oriented triangulation framework; relating five research types to two domains, along three fundamental tradeoffs in choosing an HCI method.

2.3 Three trade-offs

Many demarcation papers provide a classification of epistemological practices based on their underlying research traditions, disciplines or paradigms (see for example: Bartneck, Rauterberg 2007, Harrison, Tatar & Sengers 2007). We tried to transcend this approach by identifying the main tradeoffs that researchers have to address, independent of their research background. This is strongly inspired by the (Runkel, MacGrath 1972) framework which classifies social science methods based on universal research concerns such as generality across actors, precision of measurement and system character of context. We feel such an axiology is a much better candidate to facilitate multidisciplinary cooperation and constructive debate about mixed method approaches, than a focus on the traditions or origins of the differences between HCI researchers.

2.3.1 Rigor or Relevance.

We faced the first tradeoff immediately when we discussed the two domains of HCI. Hevner et al. (2004) propose two research cycles for design sciences. First there is a relevance research cycle in which a researcher learns about and tries to improve the application domain (e.g. work practices in a hospital). Second, there is the rigor research cycle in which a researcher learns from available work (e.g. related solutions) and contributes new work (e.g. a novel approach to the problem). Researchers from different backgrounds may differ in their preferences for the relative importance or the order in which they want to address rigor and relevance, but both are shared long term for goals HCI. Since they are hard to optimize simultaneously within a single study they need to be triangulated.

2.3.2 Certainty or Completeness?

A second distinction is the tradeoff between *certainty* and *completeness*. This is taken from the (Runkel, MacGrath 1972) framework. They distinguish between the concerns for precision of measurement versus system character of context. A researcher opting for precision of measurement tends to use methods like *laboratory* experiments or judgment tasks. A researcher that values the system character of context would rather chose *field* studies or ethnography. In the long run it is important to 'see the whole picture' and to 'understand the context' and also to be 'certain' of your theories, ideas or solutions'. But this requires triangulation, as the values cannot be addressed with a single method.

2.3.3 Inspiration or Data?

A third tradeoff is a pragmatic version of a prominent debate in the demarcation literature, which has been traced back by (Dorst 1997) to the philosophical distinction between *positivism* and *phenomenology*. Positivists hold that research should

discover regularities in the objective reality through the scientific method. 'Technical rationality', 'Rational problem-solving' (Dorst 1997) and the 'cognitive science model' for HCI research (Harrison, Tatar & Sengers 2007) are part of the positivistic paradigm family. Phenomenologists, in contrast, study the subjective experience of the researcher. 'Constructive Design Research' (Koskinen et al. 2011) 'The Phenomenological Matrix' (Harrison, Tatar & Sengers 2007) and 'Creative Design' (Wolf et al. 2006) can be considered part of the phenomenological paradigm family.

(Dorst 1997) depicts positivism and phenomenology as incompatible paradigms, which creates clarity in the epistemological debate, but which does little justice to pragmatic HCI researchers who manage to combine methods from both traditions. Therefore, we narrowed the distinction down to two different views on the role of the researcher in an HCI project. In the phenomenological tradition, HCI research can embrace the researcher as an active, reflexive, participant who organizes his work to strengthen his personal intuition or inspiration. We call these methods inspiration-oriented methods. In the positivist tradition, the researcher can take the role of objective or neutral observer of reality. We call methods that try to ensure this neutrality: dataoriented methods. In the long run most HCI projects require moments of personal researcher involvement and more distanced approaches, which makes triangulation desirable. We depicted the inspiration versus data distinction in color coding within the five circles of the framework.

2.4. Five location metaphors

Having set out a space in which we could plot HCI methods and set out triangulation paths, we can add a labeling of the methods in different areas of the framework. (Koskinen et al. 2011) discuss three metaphors for what they call 'constructive design research': *lab*, *field* and *showroom*. These metaphors are locations or places where certain types of research can take place (so where methods are executed). Both the metaphorical approach as the specific metaphors suited our framework, but we had to add two metaphors (*library* and *workshop*) to cover all the distinctions we wanted to make in our framework (see **Figure 1**).

2.4.1. Field

Field methods, often borrowed from interpretive social science (Oates 2005), aim to capture the context of design (Koskinen et al. 2011), or in the terms of our framework: aim to get a *complete* understanding of the application domain (addressing the concern for *relevance* of the study). There are data-oriented field methods such as contextual inquiry and inspiration oriented field methods such as cultural probes.

2.4.2. Library

The library setting contains a collection of methods which enable the researcher to obtain insights into the relevant, available work. Literature studies, benchmarking and competition analyses are all library studies. A library study may be inspirational or data oriented, but it always aims to get a better connection with and a complete picture of available work that may be relevant to the research problem (addressing rigor and completeness).

2.4.3. Workshop

Most software engineering disciplines (Hevner et al. 2004, Oates 2005) and the research through design community (Koskinen et al. 2011, Zimmerman, Forlizzi & Evenson 2007) consider creating artifacts an important part of research and development efforts. We define 'workshop methods' as methods which aim to improve the developed solution without a direct reference to the domain of available work or application context. This includes sketching and prototyping. Workshop methods could be inspirational (such as through creative and systematic exploration of the solution space in a 'form study') or data oriented (such as iteratively improving the objective performance of a system following some predefined method). (Hevner et al. 2004, Zimmerman, Forlizzi & Evenson 2007, Oates 2005) and (Wolf et al. 2006) propose academic criteria for judging the quality of workshop methods.

2.4.4. Lab

Following (Koskinen et al. 2011) we used the lab(oratory) metaphor to cover methods that aim to reach empirically grounded conclusions about a design. We consider any method that aims at testing an aspect of a proposed solution, against aspects of (or goals for) the application domain, optimizing the certainty of the conclusions to be a 'lab method'. Lab studies complement field studies with their concern for relevance, but field studies are more suitable for getting an overview, while the lab studies aim at certainty in their results.

2.4.5. Showroom

We broadened the showroom metaphor used by (Koskinen et al. 2011) to include any method that helps to make the work more reusable by other researchers. For example: when the performance of a pattern recognition algorithm is compared to that of other approaches to the problem it helps researchers to assess the potential of the proposed method. This is a (data oriented) showroom study. An example of and inspiration oriented showroom study could be if the researcher critiques his design in comparison with other designs that served as an inspiration in earlier stages. Also the creation of design frameworks or guidelines, intended to highlight considerations that go beyond individual designs. Showroom studies typically optimize rigor and certainty over other values.

3. TESTING THE FRAMEWORK

To explore its usefulness we applied the DOT-framework to 10 recent HCl papers. For all papers we regarded the research in the paper as a triangulated research effort in the DOT-framework. We wanted to learn which difficulties occurred when classifying the research using DOT. Also, we tried to see if the application of the framework would raise methodological issues which were not addressed by original authors. We felt that - if the DOT-framework is suitable to strengthen the debate about mixed-method approaches in HCl, such questions should arise.

We used an a-select random sample of 10 papers (about 10%) from the NordiCHI 2012 proceedings for this study. NordiCHI is one of the larger European conferences and since our sample covered a reasonable portion of its proceedings it should give a fair representation of work done in the (European) HCI community. Our sample consisted of 8 long and 2 short papers, including a wide range of topics such as end user programming (Ardito et al. 2012), augmented reality (Grubert, Grasset & Reitmayr 2012) and usability testing (Følstad, Law & Hornbæk 2012).

We scored the methods in the papers according to the five research locations of the DOT-framework. We made a distinction between a thick and a thin path through the framework. The thick path listed the main contributions of the paper, usually 2-4 chunks of research. The thin path listed other research efforts which were touched upon but not explicitly described as a study in the paper: such as a small literature review (library study) in all papers or a small section with 'implications for design'. In particular we only considered a literature review as part of the thick path if it could be counted as a separate contribution of the paper. The DOTframework defines research as instrumental to a development challenge. However, not all papers stated the challenge to which their paper contributed. In these cases we inferred the most likely development challenge from the research.

3.1. Results

Table 1 summarizes the classification of the 10 papers in the framework. We marked the *thin path* with an ~. The numbers refer to the order in which the *thick path* studies were conducted, inspiration oriented methods were further labeled with a —i mark and data oriented methods with a —d mark.

Most papers could be described in terms of the DOT framework. However, there were two ambiguous method placements. In their paper about the design of remote assistance systems with mobile devices (Giusti et al. 2012) used a lab experiment to find out how people would set up remote assis-

tance situation with mobile devices. This paper could be classified as a field study carried out in the lab (aiming to get a complete picture of human behavior in the –now- simulated application context) or a lab study (aiming to get certainty about certain aspects of the application context). We decided to classify it as an inspiration-oriented lab study, because the researchers tried to create the, in their view, representative situations for the application context; thus exhibiting a substantial amount of experimenter control.

Reference	Library	Field	Workshop	Lab	Showroom
(Ardito et al. 2012)	~		1-i	2-i	
(Brown, Lindgaard & Biddle 2012)	~	1-d			2-d
(Clarke, Wright 2012)	~		1-i	~	
(Dalsgaard, Halskov 2012)	~		1-i	2-i	3-i
(Følstad, Law & Horn- bæk 2012)	~	1-d			~
(Freitag, Tränkner & Wacker 2012)	~		1-i	2-d	
(Giusti et al. 2012)	~		1-i	2-i	3-i
(Grubert, Grasset & Reitmayr 2012)	2-d	1-d	3-i	4-i	~
(Hansen et al. 2012)	~		1-d	2-d	
			4-i	3-i	
(Laporte, Slegers & De Grooff 2012)	1-d		2-d	~	3-i

Table 1: description of DOT-framework paths for 10 HCl papers.

A second difficulty arose in classifying workshop methods with a strong user involvement. (Laporte, Slegers & De Grooff 2012), for example, explored a new way of segmenting personas and (Clarke, Wright 2012) explored the elicitation of crosscultural stories in a series of co-creation settings. Such case studies of exploring new user-centered-design methods have 'workshop' properties because the execution of the method is one central object of study, but they also have 'lab' attributes because, collaterally, they explore the applicability of the method in the application domain. We classified them as workshop methods in the thick cycle, and added lab to the thin cycle.

In general we may say the concerns highlighted in the DOT-framework are valid but that not all methods can be put in a corner of the framework. Moreover the concerns are sometimes addressed without a full study (thin cycle).

3.2 Discussion

(Hevner et al. 2004) propose two research cycles for design science: a *relevance cycle* and a *rigor cycle*. We amended this work by distinguishing 5 separate types of research, addressing their concerns in different ways. The diversity of approaches which we found in our sample supports this amendment. For example: we did not find a paper which includes a full relevance cycle (field, workshop, lab) and only one to include a full rigor cycle-library, workshop, showroom (Laporte, Slegers & De Grooff 2012). There appear to be different recurring patterns of mixed-method approaches though. Identifying these with more certainty is part of our future work.

The DOT-framework can be used as a quick check on the 'balance' of the work presented in a paper. Typically, when we tried to draft next steps for the papers in the sample, these had a complementary research pattern. One example is the work by (Hansen et al. 2012), who explored the idea of location based voice messages through 'talking badges'. Their work focused on workshop and lab; i.e. choosing the best implementation for the badges and testing some scenario's with users. The results where positive from a technical perspective, but disappointing from a user perspective, suggesting a field study or even a complete relevance cycle (field, workshop, lab) to find apt niches for the system as a follow up. This follow up is suggested by the authors in their conclusion section, but it also readily follows from the profile of the original study in the DOT-framework. As researchers cannot address all concerns of the framework in a single paper, it may be advisable to use the thin path to address those issues that are outside the scope of the paper. For example: rigor based studies could benefit from a relevance quick-scan: researchers could quickly assess the user needs around an opportunity which arises from technological developments.

Workshop and showroom approaches turn out to be prevalent steps in the papers we screened (Table 1), but the diversity in which this work is reported is large. Little consensus exists about the application of academic standards such as transparency, reliability and validity to these types of research. In particular for *showroom*, authors usually report the results and not the way these were obtained. Notable exceptions are (Brown, Lindgaard & Biddle 2012) who included a post-analysis literature study in their paper and (Laporte, Slegers & De Grooff 2012) who explicitly related their outcomes to existing guidelines.

Workshop studies show an even greater diversity and few authors take care to explicate the standards they use to report it. An exception is (Dalsgaard, Halskov 2012): who used their process

reflection tool. There are standards for these types of studies (Hevner et al. 2004, Oates 2005, Zimmerman, Forlizzi & Evenson 2007, Wolf et al. 2006), but researchers can also look at the DOT-framework. The DOT-framework suggests to make the interfacing of workshop studies with library, field, lab and showroom in the reflective design cycle explicit. In our sample this is done well by (Grubert, Grasset & Reitmayr 2012).

(Bergman 2008) points out that rethinking mixedmethod approaches also strengthens our understanding of individual methods. The DOTframework suggests a mutual focus for all five types of methods. For example: field studies need to optimize the way in which they can paint a complete picture of the application domain, while they have to deliver results in a form which is useful for an exploration of the design space, too. It is surprising we found so little comments about the mutual focus of the chosen methods, or, more general, on the interrelations of the different parts in a larger study. How does a lab study help a workshop study or vice versa? Often the 'magic' of effective mixed method design is in between methods. The DOT framework might help to dispel this magic by making questions of interrelations between methods more salient.

4. CONCLUSIONS AND FUTURE WORK

Judging from our sample, mixed-method approaches are the rule rather than the exception in HCI. We have shown our framework can be used to describe the triangulation trajectories of HCI researchers and we have shown this raises new questions about mixed-method approaches in HCI. This is a step forward, but we did not yet manage to probe into the combinatorial rationale of mixed-method approaches (Petter, Gallivan 2004), sufficiently.

We are planning a follow-up to identify mixed-method research *design patterns* within our framework. This demands closer scrutiny which is for example done for the social sciences by (Bryman 2008). He created a large inventory of reasons for mixing methods used this to study both rationale and actual use by researchers. Also, on top of a more precise scrutiny of the way in which HCI researchers mix methods we would like to explore the utility of the DOT-framework as a planning and reflection tool for research and as a tool to achieve common ground in multidisciplinary projects.

5. ACKNOWLEDGEMENT

The authors would like to thank Ton Ammerlaan, for reviewing an earlier draft of this paper.

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