The Nature of Design Practice and Implications for Interaction Design Research

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The focus of this paper is *interaction design research aimed at supporting interaction design practice*. The main argument is that this kind of interaction design research has not (always) been successful, and that the reason for this is that it has not been guided by a sufficient understanding of the *nature of design practice*. Based on a comparison between the notion of *complexity* in science and in design, it is argued that science is not the best place to look for approaches and methods on how to approach *design complexity*. Instead, the case is made that any attempt by interaction design research to produce outcomes aimed at supporting design practice *must* be grounded in a fundamental understanding of the nature of design practice. Such an understanding can be developed into a well-grounded and rich set of *rigorous* and *disciplined* design methods and techniques, appropriate to the needs and desires of practicing designers.

Keywords - Design Research, Interaction Design, Nature of Design.

Relevance to Design Practice - This paper makes the case that design research aimed at improving design practice has to be grounded in a deep understanding of the nature of design practice.

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Introduction

Dealing with a design task in an unknown or only partially known situation, with demanding and stressed clients and users, with insufficient information, with new technology and new materials, with limited time and resources, with limited knowledge and skill, and with inappropriate tools, is a common situation for any interaction designer. Dealing with such messy and "wicked" situations constitutes the normal and everyday context of any *design practice* (Alexander, 1964; Dunne, 1993; Cross, 2001; Schön, 1983; Pye, 1995; Heskett, 2002; Rove, 1987; Lawson, 2005; Thackara, 2005).

Research about design practice has shown that designers who successfully can handle complex design situations use an approach sometimes labeled as a *designerly way* of thinking and acting (Cross, 2001; Buxton, 2007; Moggridge, 2007). There has also lately been a more general and growing interest in what is seen as an increasing complexity in our society and how to deal with it (Castells, 1996; Coburn, 2006; Friedman, 2005; Gladwell, 2005; Pink, 2005).

A substantial part of interaction design research has for some decades developed theoretical approaches, methods, tools, and techniques aimed at supporting interaction designers in their practice. This research has showed significant progress, and the field is today rich with a diverse set of approaches, methods, and techniques. Some of these approaches are new constructs, but many of them have intellectual roots in other academic areas, such as science, engineering, social science, humanities, and in the traditional art and design disciplines (Carroll, 2003; Rogers, 2004). (In this paper, the terms *Human-Computer Interaction (HCI) research* and *interaction design research* are used interchangeably).

Over the last few years, criticism has been raised concerning the success of some of these contributions. It has been argued that the results are not always useful for practitioners, and that the developed approaches are too time-consuming, too difficult to learn, too abstract and theoretical, or that they do not lead to desired results when used in practice. An excellent overview and formulation of this critique is found in Rogers (2004). Rogers presents a thorough analysis of the state of the major theoretical approaches in HCI in relation to practice. She also presents empirical results that confirm her theoretical analysis. Rogers' analysis shows quite convincingly that if the measure of success for this kind of research is that it is understood and actually used in practice then the results are minor.

One assumption in this paper is that the critique presented by Rogers is valid and that it constitutes a serious and real problem for the interaction research community. Based on that assumption, I will examine why it seems so difficult for HCI research to produce results that are appreciated and useful within interaction design practice.

It is important to recognize that there exist many examples of successful HCI research reaching and influencing a large population of practitioners. This is also recognized by Rogers, and

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is something I will discuss later in this paper. It is also important to recognize that this paper is *not* about all forms of HCI research. It is only about research *aimed at improving interaction design practice.*

My main argument is that one reason why HCI research (aimed at supporting design practice) has not (always) been successful is that it has *not* been grounded in and guided by a sufficient understanding and acceptance of the *nature of design practice*. As a consequence, HCI research has developed and/or borrowed approaches and methods not always appropriate for interaction design practice, even though they may be successful in their respective "home" fields or in research settings.

In this paper, the notion of complexity, and especially the concept of *design complexity* will be used as a focal point of analysis. As mentioned above, design practice is to a large extent about handling complexity and a "messy" reality. However, the case will be made that complexity in design is not at all the same kind of complexity seen in other areas of human activity. Therefore, the notion of *design complexity* will be compared and contrasted against *complexity in science*. The purpose is to show how the underlying philosophy and principles in one area, in this case *science*, might be incommensurable in another field, in this case *design*.

The overall message of the paper is that *HCI research undertaken with the purpose of supporting design practice has to be based on a deep understanding of design as a unique human activity of inquiry and action*. I am aware that this is not news to all readers, but I believe that mainstream HCI research is still far from recognizing this, which is why it is worth exploring.

The structure of the paper is as follows. The next section will briefly position the analysis and discussion in relation to contemporary HCI research and design studies. In the following section, I will examine the notion of complexity in design and science, making the case that borrowing methods and approaches from science may not be appropriate for design practice. After that, I will argue that design practice has its own rigor and discipline that can be further developed and explicated. I will end the paper with some suggestions on how HCI research can be successful in supporting practice.

Background

HCI research has in many ways been extremely successful over the years. The basic *tool set* for interaction design practice, taught in most HCI programs, is used over and over again by practitioners in the industry. So, what is the problem?

Rogers (2004) reports that nearly all respondents in their study "used a range of design methods, including scenarios, storyboards, low-tech and software prototyping, focus groups, interviews, field studies, and questionnaires and use cases" (p. 123). On the other hand, almost no one used "predictive modeling methods, like GOMS, and only a few used software engineering methods (8 percent), experiments (10 percent), contextual design (10 percent) or guidelines (5 percent)" (p. 124). When it comes to how practitioners interpret the data and findings they gather in their design process, 85 percent said that they rely mainly on their own intuition and experience. Even though theoretical approaches were not used, respondents said they "used" individual concepts, such as affordance, context, situatedness, etc. (Rogers, 2004).

Many respondents answered that they were familiar with most major theoretical approaches in HCI but they did not use them. Rogers (2004) states that "the problem seems to be the gap between the demands of doing design and the way theory is conceptualised" (p. 123).

Rogers' study reveals both positive and problematic results when investigating how HCI research is used and viewed by practitioners. One interpretation, in line with the argument in this paper, is that the basic tool set (see above), used by many, can be described as *designerly tools*. These kinds of tools have qualities that are traditionally recognized as useful by designers. That means that they are clearly defined tools with a precise purpose that have to be used in a skillful way by a competent designer to be useful. These tools do not remove any "power" or freedom from the designer. These tools do not prescribe the overall process or demand a specific step-by-step sequence of activities that would impact the designer's own way of doing things. These tools do not demand any sophisticated theoretical understanding or knowledge. This is in line with the fact that the more intricate models that require more from the designer (such as contextual design, experiments, engineering methods) were less used in Rogers' study (2004). My assumption is that these methods would be recognized as less designerly if judged by experienced designers.

Based on the work by Rogers, I would argue that it is possible to *predict the potential success of new approaches, methods, and tools based on how designerly they are*. It is obvious though, that any prediction of this kind must rest on a fundamental understanding of what designerly means. This paper will examine what constitutes such an understanding and what are the preconditions for successful development of new approaches and tools intended to support designerly practice.

There has in recent years been a growing interest in the role and nature of design in HCI research (Winograd, 1996; Zimmerman, Forlizzi, & Evenson, 2007; Löwgren & Stolterman, 2004; Fallman, 2003; Atwood, McCain & Williams, 2002; Bartnek, 2007). We have also lately seen some knowledge-based contributions intended for design practice that are genuinely designerly and based on a firm understanding of design practice. These contributions have already had some impact and have increased the interest in a deeper understanding of design practice. Premier examples are the recent books by Buxton (2007), Moggridge (2007), and Kolko (2007). These contributions can all be seen as examples of what I am arguing for in this paper, that is, knowledge produced with the specific aim of supporting design practice that is firmly grounded in a deep understanding of design practice. It is notable that these three books are written by authors

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who describe themselves more as practitioners than researchers. They all have a strong design background and long experience in design practice.

There have also been a number of papers advocating the importance of distinguishing between design and research in HCI (Fallman, 2003; Dourish, 2006; Bartnek, 2007; Wania, Atwood, & McCain, 2006; Taylor, 2003), or that design is an appropriate model for "real" research (Zimmerman et al., 2007), or that design practice has its own rigor (Wolf, Rode, Sussman, & Kellogg, 2006; Buxton, 2007; Bartneck, 2007). These advancements, together with others (Laurel, 2003; Winograd, 1996), are promising and will over time influence the way HCI research is done. However, none of these attempts specifically addresses the question raised in this paper, which is how to improve HCI research aimed at supporting design practice.

After this brief overview, it is time to engage in the overall argumentation of the paper. In the next section, I will, as part of my reasoning, examine the notion of complexity in design practice and relate that to the notion of complexity in science.

Design Complexity

Design complexity is here defined as the *complexity a designer experiences when faced with a design situation*. Almost all design situations offer potentially infinite and limitless sources of information, requirements, demands, wants and needs, limitations, and opportunities. These "infinite and limitless sources" usually present themselves in the form of diverse technological possibilities, numerous and constantly changing contextual factors and societal preconditions, sophisticated and/or non-informed clients, customers, and user demands and desires. Even though all of these sources can inform the designer about a potential design, it is not possible to exhaustively explore them for all potentially useful information. Facing such "infinite" information sources might lead a designer (even an experienced one) to experience an overwhelming design complexity. The designer has to make all kinds of decisions and judgments, such as, how to frame the situation, who to listen to, what to pay attention to, what to dismiss, and how to explore, extract, recognize, and chose useful information from all of these potential sources. An inexperienced designer might suffer from "design paralysis" when confronted with such endless opportunities. These design situations are sometimes characterized as "under determined" problems, or in Schön's words as a "messy" situation, or in Rittel's words a "wicked problem" (Schön, 1983; Rittel & Webber, 1974).

According to the definition presented here, it is *not* possible to objectively measure design complexity. We cannot, based on some objective measurement, argue that "this situation has a higher design complexity than that situation." Instead, design complexity is the *designer's subjective experience of complexity*. This experience is a consequence of the nature of the task in the specific situation, in relation to the specific purpose, and in relation to the professional skill, competence, and experience of the designer. This means that one designer might experience a particular design situation as complex, while another might not.

Design complexity, as defined here, is not anything new. It is a classic problem that has been addressed in many academic design disciplines, and interaction design is no exception. The assumption made above—that designers are experiencing an overall increase in design complexity—has been recognized in the field of interaction design, even though it is not always framed as design complexity (Carroll, 2003; Löwgren & Stolterman, 2004; Maeda, 2006; Norman, 2004; Krippendorff, 2006). Some of the established theoretical attempts in the field place a strong emphasis on finding ways to cope with complexity, usually by offering approaches intended to dismantle the complexity of reality, at the same time as they offer ways of understanding its richness (overviews are found in Carroll (2003) and Rogers (2004)). There are also some newer attempts within the field of HCI explicitly focused on complexity (Johnson, 2005).

Most approaches and methods are aimed at *reducing* complexity in some way, but reducing design complexity is not an easy task. If it were, we would probably see a lot of approaches offering simple solutions at a low "cost." Instead, it seems, as Rogers shows, as if attempts to reduce or control design complexity in many cases lead to highly time- and energy-consuming approaches. It seems as if the design approaches themselves become too complex.

Complexity, Control and Richness

When it comes to reality as we experience it, our *lifeworld*, it seems as if humans, at least in the Western societies, strive towards control, and try to move away from the natural or from nature (McCullogh, 2004; Buchanan, 1992; Thackara, 2005). It seems as if Western culture is inclined to create artificial environments in which everything can be controlled.

In the attempt to create desirable environments, humans try to reduce complexity, to establish control, by making things *simpler* (Greenfield, 2006; Janlert & Stolterman, 1997; Maeda, 2006; Norman, 2005; Thackara, 2005). But rather than being a universal human ideal, simplicity is also disapproved of and looked down upon in our everyday lives. "Simplicity" sometimes provokes condescension and even contempt. Humans seem to seek and enjoy certain experiences of complexity. In some contexts, complexity may be understood as *richness*, generally found to be a positive and desired quality. The experience of being in a forest, with its overwhelming richness of different life forms and natural structures, is seen as richer than being in the controlled and simplified environment of a park. The simpler an environment is, the easier it is to understand and deal with, but at the same time, the more it lacks the richness and stimulus that we seem to appreciate and enjoy (Csikszentmihalyi, 1990; Norman, 2004).

So, complexity does not only bring problems, it also brings positive experiences. Complexity is not just a necessary "evil." Given the right circumstances, direct encounters with the complexity of a system can give us positive experiences of challenge, fullness, and entertainment, as well as aesthetic and sublime experiences, and can spur and develop our abilities and ambitions, and maybe even push us to develop our minds and characters (Csikszentmihalyi, 1990; Nelson & Stolterman, 2003).

There is apparently something intriguing about complexity. It constitutes a *challenge*, something we can explore and experience, something we can attempt to learn, to master, something that can send us off into new and unpredicted directions—almost like an adventure.

It seems as if *design complexity* also can have positive values, maybe even an *entertainment* value. A design task that is *too* simple might be considered boring. It is to some degree the complexity of the design task that makes design such an entertaining and rewarding enterprise for the individual designer. This aspect of complexity as a balance between challenge, skill, and achievement and as a source of personal enjoyment and development has been developed in detail with the concept of "flow" (Csikszentmihalyi, 1990).

Design complexity is therefore not necessarily in itself a problem. It is obviously something that gives designers rich experiences and variation, and makes it possible for them to be surprisingly creative in their design adventures. Complexity is probably even a required condition for innovative and creative design to happen.

Even though many would agree with this positive understanding of design complexity, there still exist a strong desire and striving for approaches that can be used to handle complexity in a more structured and organized way. In the search for such approaches it seems as if many turn to science—a tradition known for its ability to deal with complexity and its well-developed methods for doing so. The question then becomes: Can science provide interaction design with tools that are suitable for handling *design complexity*?

Complexity in Science and in Design

It is generally accepted that science has been extremely successful in dealing with complexity in the process of uncovering the mechanisms and structure of reality. But are the underlying principles of scientific methods and approaches transferable and suitable to *design practice*? I will argue that they in general are not. I am aware that this is not news within the international design research community, where the question of the relation between science and design has been studied and where such study has led to theoretical contributions that have proven invaluable in this discussion (Simon, 1969; Rittel & Webber, 1974; Alexander, 1964; Cross, 2001; Pye, 1995; Krippendorff, 2006; Nelson & Stolterman, 2003; Lawson, 2005).

When methods and approaches are borrowed from science without a sufficient understanding of design practice, it has sometimes led to situations in which scientific methodological principles have been adapted and radically changed to better suit design practice. This has in some cases led to severe criticism, since it has been seen as resulting in distorted versions of and "sloppy" use of established scientific methods, as is the case between "real" ethnography and the quite popular "quick-and-dirty" ethnography (Dourish, 2006). Another example of a science-based approach that has been adapted by design is the *controlled experiment*. This method has mostly been adapted and used in the area of interaction usability. A controlled experiment is, in science, a way to restrict and isolate variables that might influence the outcome of the experiment. The purpose is to find a way of measuring the role of a small number of variables. However, with the growing understanding of interaction as an overall *experience* including all aspects of the design, and the importance of *in situ* studies, and the notion of *emergent qualities* as a result of the designed composition, the controlled experiment if copied from science does not fit the needs of design practice.

I will argue that the remedy for this situation is a better understanding of how fundamental scientific methodological principles differ from what is needed in design practice. This is of course not important for the well-being of the scientific tradition and its practice, but it is important with regard to the possibility of building and formulating an independent philosophical foundation for design that can inspire attempts to develop new designerly approaches.

Complexity in Science

Complexity in Science has its place within all forms of scientific and research activities, and it influences our ability to explore, understand and explain reality as it is. Reality is, of course, of infinite complexity and may therefore never be fully explored or understood. Time or resources do not, however, limit science as a project. Science is, if seen as a project, something humans will continue to work on forever, or as long as it takes, or as long as we are curious. The aim of science is to formulate universal knowledge that explains the complexities of reality on a level removed from specifics and particulars. With the risk of being overly naive, I want to quote Webster's definition of science (n.d.):

> "knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method"

and "scientific method" is defined as:

> "principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses"

Within the scientific project, the focus is on regularities, mechanisms, patterns, relationships, and correlations with the attempt to formulate them as knowledge, preferably in the form of theories. The intention is to form theories that constitute knowledge that is valid and true at all times and everywhere. The knowledge should also be something that is possible for other researchers to reproduce and should be completely detached from and not influenced by the researcher. There cannot be any influence from the person conducting the research. If science is successful, that is, if knowledge and theories are created and corroborated within a research community, then the complexity of reality is seen as to some degree explained or at least reduced.

This description of science is of course extremely crude and does not take into account the vast richness, diversity and controversies that exist within the different scientific communities, which are well documented within the disciplines of sociology

and the philosophy of science. But this description of science, however crude it might be, is still useful in the present context and for the specific argumentation at hand. It provides us with a simple description of a relatively well-known intellectual tradition and practice against which design, as another tradition of inquiry and action, can be contrasted.

Complexity in Design

Let us move on to the second type of complexity, *design complexity*. In contrast to the scientific focus on the universal and the existing, design deals with the *specific, intentional* and *non-existing*. Interestingly enough, dealing with design complexity involves almost fundamentally opposite goals and preconditions as does the scientific approach. This is especially true when it comes to the notion of universality. In design practice, the goal is all about creating something *non-universal*. It is about creating something in the world with a *specific* purpose, for a *specific* situation, for a *specific* client and user, with *specific* functions and characteristics, and done within a *limited time* and with *limited resources*. Design is about the unique, the particular, or even the *ultimate particular*. Designers have to address the people and situations *at hand*, and the desires and needs at hand, while taking into account the limited time and resources at hand (Buchanan, 1992; Krippendorff, 2006; Nelson & Stolterman, 2003). This can be seen as the invariants of design and as universal "features of design task environments" (Goel & Pirolli, 1992).

Design practice is about the creation of a desired reality manifested as an ultimate particular. The *ultimate particular* is a design concept of the same dignity and importance as truth in science (Nelson & Stolterman, 2003). The ultimate particular is the actual final manifested outcome and as such a result of an intentional design process. A digital artifact or an information system implemented in a specific organization is an ultimate particular. Such an ultimate particular may be similar to a specific type or class of systems, but it is nevertheless a unique particular. This means that if the system is not satisfying the demands and needs of the organization, it is not reasonable to argue that, "Since this system works well in another organization, it can't be the system that is causing the problems" or, "Since this system was designed in accordance with agreed upon methods and techniques, there can't be anything wrong with the system." Each system, each design, even if exactly the same as another, makes up an ultimate particular that has to be understood in a designerly way as evoking emergent qualities in the composition made up by the system and the organization together.

The meaning of the ultimate particular is not to be confused with whether the design is *unique* or not. An object is unique only if it exists in one or maybe few exemplars. It is not unique if it is mass-produced and exists in thousands or millions of copies. However, each of these exemplars is still an ultimate particular in its specific *use context*. And a designer always designs for that specific use context. This is why notions such as *qualities-in-use* and *experience* have lately become core designerly concepts in interaction design (Ehn & Löwgren, 1997; McCarthy & Wright, 2004).

Design practice is also, as mentioned earlier, different from science in that there are always time and resource limitations. Science has similar limitations, but since science, as a "grand" project, is aimed at revealing truth, the limitations are only local and temporary. That is why there is the notion of cumulative knowledge production in science, wherein each new contribution has only to deal with a minute aspect or part of the field, and can still be valuable. In design you have to design the "whole," and you cannot reduce design complexity by limiting yourself to those things that you have the time or resources to handle, or those things that you have sufficient knowledge and information about. For instance, you cannot limit the design of a new mp3 player to concerns about the shape and form of the physical object while ignoring its functional and interactive aspects. In science this is done by deliberate and careful separation of aspects, with the purpose of reducing complexity by focusing on one relevant aspect or variable at a time. In design, on the other hand, methods and approaches have to take the whole composition, the emerging qualities of the whole, into account, which of course creates distinct methodological requirements when it comes to testing and evaluation.

Finally, while the measure of success in science has to do with how well the researcher has performed the research process in accordance with agreed upon methodological standards, the measure of success in design is all about the outcome. The quality of the final outcome (the design) is not a question of how well the designer performed the design process, or whether the designer followed a correct design process, whatever that would mean. This has been recognized in interaction design with the advent of notions such as *experience design* (McCarthy & Wright, 2004). The final measure of success for a design is something revealed in location, in real use, and over time.

Contrasting the Two Forms of Complexity

The two forms of complexity discussed here are, unfortunately, commonly mixed and seen as related or even similar, with the consequence that the remedy for dealing with one type of complexity is copied from one to the other.

Several influential design thinkers have historically addressed the relation and dissimilarity between science and design that is discussed here. Herbert Simon made such an argument in his famous writings on design (Simon, 1969). He did not argue that we have to abandon the idea of scientific methods as a ground for design, but he did advocate that these methods have limitations and that we could only talk about "bounded rationality" when it comes to design. He also made a clear and important distinction between the nature of the "real" world (the realm of science) and the artificial world (the realm of design). Rittel and Webber (1974) argued further that real-world problems have the characteristic of being "wicked problems," and as such they are not "solvable" and have to be approached using completely different means. Donald Schön (1983) developed a similar but more radical idea. According to Schön, people try to use "technical rationality" to solve problems that are not "solvable" or, to be more precise, that are not even "problems." Design is about "problem setting," not

about "problem solving," according to Schön. He also argued that design is all about "messy situations."

In messy situations, the methodological underlying principles developed within the tradition of science are not necessarily suitable; in fact, Schön claimed that they cause more problems than they solve (Schön, 1983). Schön specifically developed his argument in relation to education. He argued that if "technical rationality" is used as the foundation for professional higher education, it hinders students from developing real design competence and design skills, while allowing them to be trained in techniques and skills not appropriate in design (messy) situations.

It is probably fair to argue that while Simon tried to bring scientific approaches and design together in some blended fashion, both Rittel & Webber and Schön argued that they are incommensurable. Schön's thinking was deeply rooted in the philosophical tradition of pragmatism and heavily inspired by the philosopher John Dewey. Based on the pragmatists' tradition, the notion of outcome (product) in any activity is stressed more than the method (process). Truth is for Dewey and Schön not defined by the level of methodological refinement and how well methodology has been followed (as in science), but instead the outcome has in itself a special standing in relation to intention and worth. Zimmerman et al. (2007) have presented a model for design research that is heavily influenced by these ideas. They argued that it is possible to use design practice as a model for HCI research. This is an excellent suggestion that enriches our understanding of HCI research and opens up the way for new interesting forms of HCI research.

It is important to remember that the argument here is not that design research cannot be done in a scientific way. Design research conducted according to strict scientific procedures can produce highly valuable knowledge for practicing designers.

To summarize this section, I have made the argument that dealing with complexity in science and in design are different activities with different purposes, outcomes, and measures of success. Acting on design complexity in a designerly way demands *appropriate* approaches, methods, techniques, and skills. Science has over time developed detailed, rich, and diverse understandings of its purposes and approaches. Methodological rigor and discipline is at the core of what science does. I am advocating that there is a need in HCI research for a similar philosophical and methodological understanding of *what constitutes the rigor and discipline of design practice* in order to better support that practice.

Acting Designerly with Discipline and Rigor

While having demonstrated the difficulty of handling design complexity, it is obvious that *good designers can handle design complexity*, and they can do it in ways that lead to innovative and surprising results that people appreciate and value as wonderful examples of good design. Even in the most demanding situation, one with a design complexity that most people would agree is overwhelming, some designers are still able to deliver a design that seems both to "conquer" complexity and to be surprisingly functional and appealing. So, design complexity is apparently possible to deal with, and there seems to be a designerly approach that *is* practical and that *can,* despite complexity, deliver good design outcomes.

Wolf et al. (2006) make the case that to act designerly in interaction design requires a highly *disciplined* and *rigorous* process. One of the most common misunderstandings about design is that since it is not as intellectually and methodologically well developed and refined as the scientific approach, it is seen as fuzzy, intuitive, subjective, and difficult to grasp. Sometimes this fuzziness is even seen and labeled as irrational. And of course, sometimes it is. Bad design practice is as fuzzy and irrational as bad scientific practice. The point is that even though the design process is not structured in the way other rational processes are, it does not mean that we have to see the process as a "black art" (Wolf et al., 2006). Instead, design has its own internal structure, procedures, activities, and components that are well recognized by skilled designers and that also are explicated in the design literature mentioned above.

A designerly approach has been "used" by humans throughout history, at times when they have approached and dealt with an immediate, rich and complex environment, and have changed that environment to align with their needs and desires. However, this is not a tradition that has developed into an intellectual discourse with theories and externalized insights in the same way as within the scientific tradition, or within other traditions such as religion or art. But, there are intellectual foundations and fundamentals that support design thinking and acting, and there is a *rigor and discipline in design*. Below, I will briefly touch on some of the aspects that constitute the rigor and discipline of design. This is far from a comprehensive overview, but it is a start.

Existing Understanding on Design

Even though I have argued that an understanding of design practice needs to be developed, there is no need to start from nothing. If we turn to the broader, generic fields of the theory of design and the philosophy of design we can find excellent texts that provide fundamental understandings of design. There are a number of researchers that have provided insights that are already considered to be seminal (Cross, 2001; Dunne, 1993; Krippendorff, 2006; Nelson & Stolterman, 2003; Lawson, 2005; Rove, 1987; Pye, 1995; Schön, 1983).

These texts, taken together, outline an intellectual progression from an early engineering-based understanding of design, fostered in a scientific tradition, that has developed into a modern designerly-oriented understanding of design practice. These authors do not provide *one* clear understanding or theory of design; instead they give us several different, and sometimes even contradictory, explanations of what the foundations of design are. But, they all argue that there exists something that we can label a designerly approach, and that design is a unique human activity deserving its own intellectual treatment. They all also agree that such an approach is different from the scientific approach and

is solidly based in design practice and in the situated and the concrete. It is an approach that deals with particulars and with the richness of reality, and with the purpose of creating and forming new realities.

These authors also argue, in their own ways, that tools and methods that create predefined ways of approaching reality are not helpful in design. Instead, all tools, techniques, and methods supposed to support design practice have to be intentionally incorporated as part of a situated designerly approach by the acting designer. As a consequence of this, it becomes important for those who produce support for design practitioners to make that "incorporation" into the designer's own approach possible. For example, Rogers (2004) makes the case that even though designers do not necessarily "use" certain theoretical concepts, they recognize them and are influenced by them, as can be seen with the notion of *affordance*. The idea of affordance does not predefine the interaction design process in any way, but it can still be "used" by a designer as a "tool" for inspiration. This means that the notion of affordance can easily be incorporated by a designer and adapted to any kind of process suitable in a specific situation.

Prepared-for-action, not Guided-in-action

These authors argue that methods and approaches aimed at improving design practice have to be designed with a sincere respect and understanding of the positive aspects of the complexity and richness of the particular qualities of the case at hand. Most of these authors argue that the only way to keep that richness is for the designer to be fully immersed in the context of the case and to make sense of that context based on an understanding of the particular situation, and then to create an appropriate approach for the specific design task at hand. This fundamental idea can be condensed into the notion that designers can be *prepared-for-action* but not *guided-in-action* by detailed prescriptive procedures. When a designer is in a complex design situation, she has to act on that situation with a regard for all of its richness and complexity, and in a way that is appropriate for the specifics of that situation. Design education can prepare for such situations, but it cannot prescribe how to act in them. If someone is not prepared to handle such complexity, methods and techniques cannot with any "guarantee" guide anyone through such situations. One example of an approach that manages to fulfill this requirement is manifested in the notions of *reflection-in-action*, *reflection-on-action* and *design repertoire* by Schön (1983). With these concepts Schön intended to give designers *tools for reflection* that they can use to continuously develop their design abilities. Through these processes of reflection, a designer can develop a useful repertoire of design ideas or design concepts to be used in future design situations. The design approach that Schön argues for and the concepts that he introduces have been influential among practitioners. Schön managed to find a way to describe design practice that can be recognized by practicing designers, as well as providing concepts that can be used as intellectual tools in the planning and development of the design process. And he did this without prescribing the process on any detailed level. His approach is therefore a good example of a strategy based on the understanding that designers should be supported by being "prepared-for-action" and not "guided-in-action."

Design Rationality

Designers in action are commonly described as being intuitive or sensitive to a situation. Sometimes the process is even seen as badly structured, subjective, or fuzzy. This same process can, however, also be seen as a highly rigorous and disciplined way to act if seen from a designerly point of view. It is possible to understand and describe the underlying rationality of design, and such an understanding of design rationality has been labeled with concepts such as the *thoughtful designer* (Löwgren & Stolterman, 2004) and the *reflective practitioner* (Schön, 1983). These authors, and others such as Buxton (2007) and Krippendorff (2006), have outlined what they see as the *rationality of design* and what is the disciplined activity of design. It is obvious that many of these attempts show strong similarities when it comes to what the authors see as acting rational as a designer. This means that since it seems possible to talk about a rationality of design practice, it is also possible to build a deeper and explicated understanding of what defines the *disciplined behavior of a designer*. More detailed descriptions of what it means to be a disciplined designer can be found in Kolko (2007), Buxton (2007), and Moggridge (2006). These authors show, for instance, that *sketching* is at the core of design. Sketching is a disciplined way of exploring the relationships between diverse design ideas, between a whole and details, between form and function, between appearance and materials, etc. These authors also mention that a rational designer works on *many alternative designs in parallel* in an *iterative way*, while going back and forth between the whole and the details. This way of doing design is not a choice. It is at the core of what it means to act in a *rational, disciplined, designerly* way.

Design Judgment

To act in a designerly way, and to be able to use judgment and intuition as precise intellectual tools in the right situation and for the right purposes, is of course extremely difficult and puts a lot of pressure on the designer. This is why the *designer's judgment* becomes the primary "tool" in dealing with design complexity in a designerly way. One way to develop the skills of rigorous and disciplined design practice is to focus the training and education of designers around the notion of Schön's "repertoire," and to intentionally help students build a *heightened sensibility of quality and composition*, all with the purpose to *prepare-for-action*. Within several design fields this has been developed into disciplined educational structures and processes built around concepts and activities such as the use of *design studios* and the act of *design critique*. Architecture, product design, visual design, and other fields have to some detail refined these approaches, whereas such approaches have not to any great extent been developed in interaction design education, even though there is a growing interest. These educational approaches are similar to what is actually used in design practice, and there are several anecdotal and experienced-based reasons to believe that they serve their purpose well; for instance, some highly successful design firms, such as IDEO, are famous for their rigorous designerly approach.

Design Argumentation

Another aspect of the idea of acting in a disciplined way is that, both in science and design, we have to *argue* for our outcomes and their value. In science this is done by making a convincing case that the research has been conducted in accordance with the rules and procedures of an agreed-upon scientific method. In design practice this is accomplished by making our judgments visible and open for critique. One unique aspect of design is how the design itself becomes a vital part of the argument (Krippendorff, 2006; Schön, 1983). Similar ideas have been introduced in HCI with the notion of "artifacts as theories" (Zimmerman et al., 2007; Dillon, 1995; Carroll & Kelloww, 1989). Designers need to argue for their designs, but the grounds for what constitutes a good argument are different from what constitutes an argument for a scientific result.

Design of the Design Process

A final aspect of being rigorous and disciplined is concerned with process awareness. Design and science both require close attention to the process, but for different reasons. While researchers spend time designing and planning their research process to concur with the established and universal standards of science, designers need to design their process to accommodate the specifics and unique conditions of the task at hand. Buxton (2007) writes: "In order to create successful products, it is as important (if not more) to invest in the design of the design process, as in the design of the product itself" (p. 408).

Taken together, these aspects constitute only a small fraction of what can be seen as the core of the discipline and rigor of design practice. The message in this paper is that HCI research should adopt further exploration and development of design rigor and design discipline in interaction design practice as one important part of its research agenda.

Implications for Research

There is a growing interest in research aimed at supporting design. This is seen, for instance, in the strong interest in the notion of *design science,* a concept recently being explored by many researchers and strongly pushed by funding agencies. In the National Science Foundation (2004) synopsis of the Science of Design program, it is stated that, "Complex interdependencies strain our ability to create, maintain, comprehend and control these systems." It further states that in order to rectify this problem, "The goal of this Science of Design solicitation is to develop a set of scientific principles to guide the design of software-intensive systems." The basic idea seems to be to make design more reliable by making it more "science-like." The success of this initiative is therefore seen as dependent on how well methods from science can be transferred to design. The measure of success for the program is stated like this: "Ten years from now, the design, construction, testing, commissioning, and modification of complex, software-intensive systems should be based on a coherent, systematic body of scientific knowledge and rationalized experience." It is of course possible to develop rigorous approaches that can support certain specific forms of design practice, especially the design of complex technological systems that need reliable solutions that can guarantee stable structures and mechanisms. I would argue, though, that it is unfortunate if the design science approach is also adopted for the design of interactive systems. If that happens, it is likely that interaction design will end up with borrowed approaches, methods, and techniques that are not at all appropriate for dealing with interaction design complexity. In fact, it is even possible to argue that in some cases these techniques will make things worse, since they will increase design complexity instead of reducing it. Instead, what is needed is for HCI research aimed at supporting design practice to be grounded in a well-developed and designerly understanding of the design process. It is possible to suggest a number of research activities that are needed to establish such an understanding.

Theoretical Grounding

On a practical level this could mean that *readings in the theory of design and the philosophy of design* should be brought into HCI curricula and especially into HCI doctoral programs. The good news is that there is already a substantial amount of literature that can serve this purpose. For any HCI researcher trying to improve design practice by creating and developing approaches, methods, techniques, or supporting software tools, such readings should also be required.

The Study of Practice

Another implication for HCI research is that some of the time and effort now spent on developing new models, methods, and tools for practice should be devoted to careful and detailed *studies of existing interaction design practice*. In order to change design practice, we need more research that examines, uncovers, analyzes, and interprets what interaction designers are already doing.

Rationality Resonance

Studies of existing practice are important for many reasons, including from a pedagogical perspective. Practitioners are usually not inclined to listen to researchers who do not express sincere respect for their practice and who cannot show that they have a deep understanding of the preconditions and reality of that practice. This relationship between *suggested practice* and *existing practice* has been labeled *rationality resonance* (Stolterman, 1994; Russo & Stolterman, 1998). Any attempt to introduce a new "rationality" into practice has to resonate with the already existing rationality. Without such resonance the introduction will be extremely difficult. It is reasonable to assume that approaches not used by practitioner (as shown in Rogers, 2004) do not resonate with what practitioners experience as the nature of their existing practice. Serious study of practice is a source of invaluable richness for any area that tries to support a specific practice.

Forms of Design Support

There is a need for studies on what kind of support interaction design practitioners actually care about and see as useful. Some research has been conducted within more general design studies

(Schön, 1983; Krippendorff, 2006). Based on these and similar studies, it seems as if (interaction) design practitioners are inclined to appreciate and use: (i) precise and simple tools or techniques (sketching, prototypes, interviews, surveys, observations, etc.), (ii) frameworks that do not prescribe but that support reflection and decision-making (design patterns, ways of using prototypes, styles of interaction, etc.), (iii) individual concepts that are intriguing and open for interpretation and reflection on how they can be used (affordance, persona, probe, etc.), (iv) high-level theoretical and/or philosophical ideas and approaches that expand design thinking but do not prescribe design action (reflective practice, human-centered design, experience design, design rationale, etc.). This list is at least partly supported by the results in Rogers (2004). I do not claim that the list is correct or in any way complete, but I would argue that closer studies and attempts to create a better understanding of a list like this is an important task for HCI research. Such an understanding would greatly support the field in its own attempts to evaluate and predict the usefulness of research attempts.

Interaction Research Measure of Success

If interaction research is able to provide support for design practice, then another question becomes apparent, namely, how to *measure the success* of such research. Rogers (2004) reports on a study in which the success of theoretical approaches in practice was measured by how much practitioners *know about* the approaches that research has developed and to what extent they actually *use* them. This is of course a first condition for success. If practitioners do not pay attention to research results that are supposed to support practice then nothing is achieved. However, the fact that methods are used in practice does not necessarily make the research successful. A method might be used, but not in a way that leads to the results anticipated by the researcher. The question could instead be: Have the research results been used *and* led to intended improvements in the final designed outcome?

All of this opens up what might be seen as the ultimate questions when it comes to research aimed at supporting practice. These questions have to do with the purpose of the intended improvement. The researcher that creates support for practice is guided by some basic values and underlying intentions behind his/her attempts. What is it that the research results ultimately are supposed to lead to? Is it to improve process efficiency or product quality? Is it to lead to new creative and innovative designs? Is it to lead to competitive designs successful on a market? Who is the support supposed to serve? Is there a "final" client? Is the purpose to support design practice in a way that would lead to a "better world"? Traditional science is guided by the search for truth, while research aimed at changing and improving "reality" always takes on *responsibility* in relation to whom or what it *serves*. This means that *HCI research aimed at changing existing practice must take on the responsibility of its own eventual success*. If change takes place, if practitioners *actually* use the research outcomes, what does this lead to and how is the researcher responsible? The overall argument in this paper is that questions like the ones above can only be answered and handled if the research is grounded in a well-developed understanding of design practice.

Conclusion

This paper is based on the idea that we need to recognize and accept design complexity as a real and practical problem that every interaction designer faces. We also need to accept that design complexity is not something that can be dealt with by the use of approaches and tools aimed at reducing complexity by "borrowing" methods and approaches from the realm of science. Instead, design disciplines such as interaction design have to develop and *foster their own designerly approach for education and practice*. The good news is that we need not start from nothing.

There exist a number of excellent design theory and design philosophy works produced by contemporary design thinkers. These authors have over recent decades produced an intellectually rich and diverse foundation of design knowledge and insights that is well suited for the field of interaction design. There also exists a solid understanding of the nature of design among skilled practitioners. This is a source that has not been fully explored and exploited in relation to the potential value it would bring. So, there is a lot of work to be done. A practice-based and philosophically sound understanding of interaction design practice can be developed into a well-grounded and rich set of *rigorous* and *disciplined* design methods and techniques, appropriate to the needs and desires of practicing designers.

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