**Grounded Design: A Research Paradigm in Practice-based Computing**

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**Introduction**

Computer science is a young, but extremely successful academic discipline. It has developed into a discipline which nowadays has its organizational instantiations in almost every academic area. At one time, the hardware of mainframe computers needed to be run in specific (parts of) buildings and interaction with machines was restricted by specific coding devices such as punch cards. However, computers today are radically different. They are mobile and ubiquitous and along with this a multiplicity of interaction techniques have been developed. Looking at the various fields of application, the origins of computer science were strongly related to scientific applications during the Second World War and the Cold War. In the business world, computing rose to importance in the already well formalized world of book keeping and accounting. However, computing technologies today, as we all know, are on their way to supporting all aspects of life.

Given this fundamental transformation in the nature of computing and its high societal relevance to all aspects of life, we argue that the academic field of (applied) computer science needs to develop its epistemological paradigm and research methods accordingly. Originally emerging at the intersection
between mathematics and electrical engineering, computer science has for a long time understood itself in terms of a structured science: applied computer science followed a positivistic paradigm, viewing itself as a formal discipline which creates generally valid knowledge, independently of the context of its application. In this tradition, quality criteria were established such as formal proofs, algorithmic efficiency, or structural elegance. However, with the increasing societal relevance of applications, computer science arguably needs to define itself as a socio-technical discipline which contributes to the solution of social problems in context. This is a process which, while underway, is a long way from completion (YOU PROBABLY NEED A REF HERE, SUCH AS BANNON, HUMAN FACTORS TO HUMAN ACTORS). While computing relies on formal methods to transform users’ input through a number of state transitions into certain outputs at the user interface, the products of this formal core of computing, as is argued throughout this book, are embedded in social practices. Therefore, the quality of formal techniques and their application is finally determined by their impacts on those practices. Since social problems and social practices are contingent on the particular context of their emergence, the knowledge derived from such a research paradigm will be local and context-specific. Consequently, knowledge gained on the interaction between computing artefacts and their impact on the social practices in the fields of their application are context specific, as well.

Ironically, the success of computing has meant that the question of the scope of the formalistic defined and positivistic applied discipline of computer science has become more pressing. Our position is that a design-oriented discipline of practice based computing is needed, one where methods and techniques can deal with the context-specificity of local knowledge more seriously.

In this chapter, we present an approach which outlines such practice based computing by building on situated design knowledge and dealing with the interplay of the social and the technical. We relate our approach to recent non-positivist discourses on design research, looking at the practices of design, their (technical) support, and the sharing of related knowledge – which from a different epistemological positioning is sometimes referred to as ‘design science’.

The chapter’s argument is structured as follows. We start with situating our argument within the state of the art of design research and describe the foundations and core principles of Grounded Design. We then introduce design case studies as a central approach in a Grounded Design paradigm and argue for the transferability of the insights gained as their central quality criteria. We finally suggest building portfolios of design case studies that facilitate their comparison and allow for bottom-up concept building across cases. We close with a discussion and conclusion.

**Design Research: State of the Art**

Like computer science, research on design has its origins in the Cold War era. The increasing complexity of artefacts created in architecture and engineering required a better understanding of design processes and practices. Zimmerman et al. (2007) point to the importance of the military sector in this context, as the military demanded more predictable design methods for the engineering of battleships, airplanes or rockets.

In his historical account, Bayazit (2004, p. 16) defines the newly emerging field as follows: “**The objectives of design research are the study, research, and investigation of the artificial made by human beings, and the way these activities have been directed either in academic studies or manufacturing organizations.**” Pursuing this goal, the design research community, like many other academic disciplines, is characterized by strong epistemological divides.
As with its origins in the 1960s, positivist perspectives dominated the newly emerging field of design research. Cross (2001) argues that the application of novel scientific and computational methods such as operations research and decision-making techniques was considered to offer considerable potential in dealing with pressing societal problems. In this sense, Buckminster Fuller (1969) called for a “design science revolution” that was based on science, technology, and rationalism to overcome the human and environmental problems that he believed could not be solved by politics and economics alone. Simon (1969) popularized this concept in his book, ‘The science of the Artificial’. In defining design as an academic field and distinguishing it from others, Simon (1969, p. 114) suggests: “The natural sciences are concerned with how things are … design on the other hand is concerned with how things ought to be.” In this sense, applied computer science should be considered to be a design discipline.

With regard to his positivist understanding of design science, Simon (1969) proposes scientific studies on how designers work and scientific methods to improve and rationalize their practices. To this end, he assumed that the understanding of the problem to be solved by an artefact is given, while knowledge relevant for problem solving is rather lacking. The practices of design, then, are construed around given (and to be invented) methods and techniques, a utility function, and the definition of constraints on their application. Based on this presumption, design is conceived mainly as the optimization process of an artefact.

This understanding of the field has been challenged and criticized for lacking practical validity. Following a non-positivist epistemology, Rittel and Webber (1973) characterized design and planning problems as ‘wicked’ – not suited to the application of scientific methods. Wicked problems imply that every solution is a “one-shot operation” which consequentially leaves "traces" that cannot be undone (Rittel and Webber, 1973, p. 163). Every wicked problem is essentially unique. If so, there cannot be any general theory which determines the right design practice or outcome. In this sense, design is by its very nature theoretically under-specified. Still, this does not imply that design decisions are arbitrary. As a consequence, designers are confronted with the dilemma that “there is no right to be wrong”; even if in such situations there is neither an ethically well-defined situation nor a sound theoretical base to differentiate right from wrong.

Schön (1983) pointed out that design, in practice, is not a linear process. Adopting John Dewey’s (1938) pragmatist theory of inquiry, Schön conceptualizes design as an inquiry process characterized by uncertainty, uniqueness, and conflict. Problems do not present themselves to the practitioner as a given, but are constructed during the course of work. Design is understood to be a reflexive “conversation” with a given situation which he characterized as “reflective practice” (Schön 1983). Therefore, he suggests developing “… an epistemology of practice implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict” (Schön 1983, p. 49). Such an epistemology is more ready to put trust in the abilities displayed by competent practitioners than the one of his positivist counterparts (see table 1). In a non-positivist understanding of design research, it is understood that the particular design communities have their own well developed practices which should not be swamped with techniques and methods derived from the sciences (and arts) (Cross 2001).

To structure the field, Frayling (1993), has introduced three different research categories: Research for design, research into design, and research through design. While research for design develops foundational insights to enable the creation of innovative artefacts, research into design investigates actual
design practices. Research through design focuses on the activities of creating an artefact with regard to a specific societal condition and documenting the process.

In the last few decades, actors with a design background have focused on design methods and techniques, and the concept of design thinking in particular has impacted the computing field (e.g., Winograd 1996; Binder et al. 2011). Two fields of applied computer science have specifically been discussing appropriate ways of adapting design research methods: Information Systems (IS) and Human Computer Interaction (HCI).¹ In the following we want to critically discuss these approaches mainly with regard to their epistemological stance and their treatment of the social ends for which IT artefacts should be created.

In the IS community, Hevner et al.’s (2004) influential paper has opened a debate on the understanding of the field and on legitimate and appropriate research methods, specifically addressing the relationship between design and behavioural research. The paper needs to be read against the background of structural problems in the IS field, specifically in the Angle-Saxon community. In the mainstream, IS research had been understood as a field of mainly behavioural research, following a positivist research agenda. IS departments following such a paradigmatic positioning suffered from serious problems, such as reduced student enrolment and soft money inputs. Against this background, Hevner et al.’s work (2004) in the MISQ journal established an alternative paradigm for legitimate IS research.

Hevner et al. (2004) provide a holistic framework for IS research by reconciling a design perspective that attempts to ultimately determine the necessary functions of IT artefacts according to given requirements with a behavioural science perspective – a perspective that suggests one should explain and predict the ways in which artefacts are used. The authors advocate focusing on the properties of technical artefacts and propose a design (and research) process which they suggest leads to their emergence. While delivering useful and useable IT, design science should, according to Hevner et al. (2004) additionally lead to results that augment the scientific knowledge base for design.

Hevner et al.’s (2004) design concept stands in the tradition of Simon’s (1969) work by assuming that there is an a priori well defined problem, typically established by the business environment, to be solved by an innovative IT artefact. The utility of an IT artefact needs to be evaluated in relation to the problem being tackled. While the content of the design related knowledge base is not too well specified, the authors speak about foundations and methodologies. Opportunities to extend the knowledge base should determine which research direction a design science project could take.

There is a certain alternative tradition in the IS community, predicated on non-positivist approaches to design research (e.g., Kuechler and Vaishnavi 2012; Goldkuhl and Lind 2010; Baskerville et al. 2009). Arguably, the best known non-positivist approach to design research in IS, is Sein et al.’s (2012) Action Design Research (ADR). ADR focuses both on the design of IT artefacts and the action that embeds these artefacts in use. It reflects the premise that IT artefacts are shaped by the organizational context during development and use and conceptualizes the research process as containing the inseparable and inherently interwoven activities of building the IT artefact, intervening in the organization, and evaluating it concurrently.

¹ Other fields of computing have applied individual methods from the field of design. For instance, the software engineering community has embraced Alexander’s (1977) approach of design patterns for the reuse of software modules. However, these approaches were rather partial, limited to the appropriation of individual methods.
Zimmerman et al. (2007 and 2010) have also spurred a discussion on the role of design research in HCI. This work needs to be read against the background of transformations in the HCI field that Bødker (2006) has called the transition from second to third wave HCI. Due to the extension of (ubiquitous) computing towards application domains such as leisure, arts or the home, design criteria such as emotionality became more relevant, supplementing traditional ones based on rationality (see for instance the discourse on ‘user experience’ (UX); e.g., McCarthy and Wright 2004). Zimmerman et al. (2007 and 2010) also point to the fact that interaction designers play a much larger role in the software industry than they do in academia. Therefore, they suggest that the HCI community should more explicitly embrace research through design approaches. They suggest expanding and formalizing the research through design approach to better understand how knowledge, or theory, is generated from this type of research. For instance, they propose a model of how interaction designers should cooperate with engineers, anthropologists, and behavioural scientists in research through design projects. That is, they basically argue for modifying designers’ practices to make them better suited to a traditional understanding of academic (even scientific) work.

Gaver has further contributed to the HCI community by means of research through design projects. With regard to the discussion brought up by Zimmerman et al. (2007 and 2010), he strongly suggests resisting an endeavour of artificial academification of design research and practices:

“Overall, I suggest that the design research community should be wary of impulses towards convergence and standardisation, and instead take pride in its aptitude for exploring and speculating, particularizing and diversifying, and - especially - its ability to manifest the results in the form of new, conceptually rich artefacts.” (Gaver 2012, p. 937)

In a similar vein, Cross (2001) had already suggested that design research should rather explicate and describe practitioners’ competencies than trying to supplant them.

In their alternative approach to generating knowledge from research through design, Gaver and Bowers (2012) and Bowers (2012) suggest constructing collections of selected artefacts a designer or a group of designers have created. By annotating such collections in different manners, comparative perspectives can be established in a designer’s oeuvre, leading to a set of transferable concepts and dimensions of knowledge derived from designed artefacts. The authors call these types of collections ‘annotated portfolios’.

In addition, Gaver recognizes the openness and vagueness of using artefacts. In his considerations about cultural probes and breaching experiments, he pinpoint that it is insufficient for design research just to design artefact and evaluate, if they have the intended effect. Instead, artefacts intervene in existing practice in an open-ended manner, and design research have to observe how people making sense it in order to understand design from a user- and practice perspective.

Höök and Löwgren (2012) also deal with the problem of transferring insights gained with regard to the design of IT artefacts. They formulate an approach which helps in the transferring of intermediate-level design knowledge. What the authors call ‘strong concepts’ reside somewhere between particular instances of designed IT artefacts (from which they abstract) and generalized theories. Strong concepts are thought to carry a core design idea about the interactive capabilities of IT artefacts. These ideas cut across particular contexts of use and even application domains to inform future design processes.
From the authors’ perspective, strong concepts somehow emerge from practices of reflection, analysis, and articulation by the designer-researcher across a longer trajectory of design work covering a number of design instances.

With Grounded Design, we follow Gaver (2012) when he rejects an academically induced formalization of the designers’ practices, as Zimmerman et al. (2007 and 2010) had suggested. We also agree with Gaver on the openness and vagueness of how artefacts are used and appropriated (see also the Appropriation Chapter). The problem arguably, however, with Gaver and Bower’s as well as Höök and Löwgren’s proposals to transfer design-relevant insights is their lack of concern for the interplay between the IT artefacts’ design and their appropriation over longer periods of time. This lack is partially grounded in a long tradition prevalent in the field of design. For instance, Cross (2001, p. 54) describes ‘designerly thinking’ in the following way: “So design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of that world.” However, and in contrast, we believe that a practice-based paradigm needs to link the artificial world with the social. Even so, there seems to be a shift in design research to take phenomena of unintended use, practice breaching, and appropriation more seriously.

The IS discourse is more interested in making the evaluation of IT artefacts in social practice a legitimate element of design research. While Hevner et al. (2004) propose a basically positivist research program, Sein et al.’s (2011) paper moves paradigmatically in a more interesting direction. However, their approach does not fully embrace the particularities of social practices and the contingencies of an IT artefact’s appropriation over a longer period of time.

**Grounded Design: Foundations and Core Principles**

In the following, we want to outline a research paradigm for applied computer science which is both design-centred and practice-oriented. Our work is in line with the non-positivist perspectives proposed within the HCI and IS communities. Following the IS tradition, we believe that the quality of IT design is finally evaluated in its effectiveness in dealing with societally relevant problems. Following the RtD tradition, we believe that the problem framing is an ongoing effort in a design effort. Only in the end is there a clear understanding of what are the societally relevant problems. Therefore, the study of an IT artefact’s appropriation is an important element of the academic endeavour. To this end, an appropriate understanding of the concept of social practice is essential to our work (Schmidt, chapter two and three, in this book).

Our perspective on social practices, inherently embracing our interaction with IT artefacts over time, is based on an understanding that our experienced reality is socially constructed (Berger and Luckmann 1984) rather than “discovered” in a world existing independently from us. Cognition evolves through neither deduction nor induction, but rather through the creative operations of abduction in concept formation and artefact appropriation (Peirce 1935).

We have developed a practice-based perspective for a number of reasons: First, it reflects the fact that cognition and knowledge are always mediated by language while being embedded in social practices. Objective cognition or ‘truth’, therefore, is not practically available. Second, the observation – and even more so the shaping – of social practices is subject to ‘double hermeneutics’: The process of gaining knowledge through concept formation is self-referential in the sense that it changes the social practice it refers to in the very moment it is performed; observing a social practice inevitably means to structure it. Third, it transcends the largely pointless sociological dispute over subjective acting versus
objective structures in comprehending human action, and it simultaneously explains both the persistence as well as the dynamics of change in social practices. Fourth, it comprehends the functional properties of IT artefacts as a product of conceptualizing social practices, while the collective appropriation of the functions for effective practical use makes them a part of these practices. It thus informs design activities as interventions in organizational development rather than as the functional shaping of useful artefacts (e.g., Stevens 2008; Rohde et al. 2009; Wulf 2009; Rohde et al. 2013, Rohde et al. 2016).

In a practice-based perspective, actions change the world, which is understood to be in a state of constant becoming. To perform desired changes, actions must figure out and to be guided by purpose and knowledge (Goldkuhl 2012). Table 1 demonstrates basic features of the practice-based perspective as compared with the positivist perspective according to the distinctive categories presented by Becker and Niehaves (2007).

<table>
<thead>
<tr>
<th>Frame categories</th>
<th>Positivist</th>
<th>Practice-based</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Paradigmatic position</strong></td>
<td>Universalistic thinking: &quot;There is nothing new under the sun&quot; (Plato)</td>
<td>Evolutionary thinking: &quot;All the regularities of nature and of mind are regarded as products of growth&quot; (Peirce)</td>
</tr>
<tr>
<td><strong>Concept of truth</strong></td>
<td>Correspondence theory of truth: True propositions map real phenomena</td>
<td>Pragmatist theory of truth: Propositions recognized as true if accepted by actors coping with the problem at hand</td>
</tr>
<tr>
<td><strong>Origin of cognition</strong></td>
<td>Ontological realism Sensual experience &quot;The mind [initially is a] white paper, void of all characters, without any idea&quot; (Locke)</td>
<td>Methodological realism Conceptual percipience &quot;Our perceptual judgments are the first premises of all our reasoning&quot; (Peirce)</td>
</tr>
<tr>
<td><strong>Relationship between cognition, object of cognition and human action</strong></td>
<td>Facts are cognizable independently of cognitive process &amp; its linguistic form Actions are caused by well-defined rules &amp; concepts</td>
<td>Facts are interpreted &amp; signified by interactively shared concepts Actions are judged by implicit rules &amp; concepts</td>
</tr>
<tr>
<td><strong>Method of knowledge development</strong></td>
<td>Inductive &amp; deductive (controlled experiments)</td>
<td>Abductive (exploratory experiences)</td>
</tr>
<tr>
<td><strong>Method of design</strong></td>
<td>Theory driven</td>
<td>Reflective practice</td>
</tr>
<tr>
<td><strong>Representatives</strong></td>
<td>Simon 1969</td>
<td>Schön 1983</td>
</tr>
</tbody>
</table>

Table 1: Comparing positivist and practice-based perspectives.

The concept of practice is, in some respects quite controversial. Schmidt describes in more detail (cf. Schmidt, chapter two and three, this volume) why that might be and takes issue with the notion of practice as ‘theory’. While understanding and appreciating that view, we nevertheless feel that something of value can be taken from Reckwitz (2002) in particular. His perspective draws on social scientists such as Bourdieu (1977, 1992), Garfinkel (1984), Giddens (1984), and Mead (1934). While their conceptual work is not at all homogenous, Reckwitz (2002) identifies core principles of a school of practice-theoretical thinking. A social practice is understood to be a mainly routinized pattern of human action
judged by implicit and explicit rules and norms. Practices are not only encompassed by mental and physical forms of activity but that is also greatly influenced by material objects, especially by tools, media, and their usage. A practice is grounded in background knowledge that is both not entirely explicit and which contains emotional as well as motivational elements.

Following Reckwitz’s (2002) elaboration, social practices can be argued to be the basic elements of sociological investigation and represent collective patterns of interaction that are reproduced in specific contexts. The situated enactment and reproduction of practices are of special interest from a design perspective. While collective patterns of interaction are routinized in some sense, concrete action is situated and deviations from routine may be occasioned by a variety of factors. Challenging practices, in design-oriented variations of breaching experiments, can help to make implicit rules visible to uncover what counts not just as deviation from the routine, but also from the norms. Challenging practices in this manner is a source for the transformation of rules and routines.

With regard to the reproduction of practices, we assume that social systems emerge and reproduce themselves through continued sense-making as well as the mutually related and coordinated acting of their members. These processes of continuous action and interaction are based on developed routines, their context-specific enactment, and assumed expectations. The reproduction of practices goes along with a related perception of the world, common language usage, and shared identities.

We suggest taking the concept of practice to be the foundation of design research (Schmidt, in this volume). Social practices in their interplay with IT artefacts become the central object of our investigation. In particular, practice-oriented approaches to design research are concerned with action and change and the interplay between knowledge, artefacts, and action (Hayes, in this volume). Accordingly, designing IT systems for effective use is seen as a multi-layer intervention into social practices. Appropriation as the effects of these interventions can only be understood in a longer time perspective (cf. Stevens and Pipek, in this volume). The practice perspective offers a thorough and adequate basis to study these interventions (Wulf et al. 2011 and 2015; Rohde et al. 2016).

Design Case Studies

Design case studies are the basic elements of our research approach. These studies allow us to understand the relationship between social practices and the design space for IT artefacts that are built to support these practices. The design of IT artefacts needs to take the given social practices into account. However, when these artefacts are rolled out ‘in the wild’, the addressed practices typically undergo changes while appropriating the artefact. We need to understand the interaction between the IT design and the appropriation activities over a longer period of time (Pipek and Wulf 1999 and 2009; Rohde et al. 2009 and 2016; Wulf et al. 2011 and 2015, cf. Stevens/Pipek, this volume).

Therefore, design case studies are typically described involving three activities that in part build on each other (Wulf et al. 2011 and 2015). Because actual design practices are reflective and iterative, these activities are treated as overlapping, interleaving, and recursive:

**Context Study:** Empirical studies of a more or less ethnographic kind (see Randall, chapter 6, this book) offer micro-level descriptions of the social practices before (and during) design-oriented interventions take place. An analysis should particularly describe already existing IT tools and media and their usage. It should also capture the practitioners’ perspectives on potential developments in technological, organizational, and social dimensions.
Design study: Grounded in the context study findings, an IT artefact is designed for and with the actors in the relevant field of practice, often using techniques associated with Participatory Design (cf. Greenbaum and Kyng 1992). The documentation of this activity should describe the resulting IT artefact as well as the process of its emergence. This includes a description of the specific design process, the involved stakeholders, the applied design methods, and the emerging design concepts.

Appropriation Study: The IT artefact is rolled out into the practice setting. Its appropriation and impact on social practices over a longer period of time is observed. We document the introduction, appropriation, and potential re-design of the IT artefact in its respective domain of practice. We are specifically interested in the transformative impact of certain functions and design options realized within the IT artefact.

This process is always a collaboration between researchers/designers and practitioners. Although there is a natural order of starting points with regard to the activities’ temporal structure, the overall approach is reflective and, therefore, iterative. The activities are not strictly consecutive, but are continuing: once an analysis of existing practices has started, it does not make sense to stop reflecting upon the trajectory of existing practice; rather it continues throughout the design and the study of the artefact’s appropriation. Once the design has started, it may be continued in several iterations, although the technology has already been introduced to potential future users.

With knowledge creation as the central goal for academic endeavour, the documentation of this process becomes essential. The documentation and analysis of design case studies is directed towards later comparison, concept building, and the transfer of insights to related but never identical domains of IT application. The activities above may offer a potential perspective to structure the data and, later on, create a narrative.

Typically, a case is a ‘natural’ unit to start working at and with: It is one set of connected activities of researchers and practitioners in one field of practice. There may be, however, difficulties of different types that make it impossible to maintain collaboration over the necessary time span of a design case study. There are basically two ways to deal with such a situation (Wulf et al 2015 and 2011):

1. Design case studies may shift over time from one field of practice to a related one. For instance, the context study may have been conducted in one field of practice, while the appropriation can only be observed in a similar, but different, field of practice.

2. Design case studies may need to be interrupted at a certain point of time, without covering design or appropriation phases. For instance, we may end up with only a study in a specific context. In this case the empirical study has nevertheless been conducted in a manner so as to explore design opportunities, and we can speak about a partial design case study.

In both cases, it is the (intended) research practice that defines the design case study. The necessity to work with incomplete or shifting design case studies may result from the practice under observation, it may also result from the resource structure of researchers.

Building concepts by comparative analysis
What can we learn from a single case - beyond the simple validation or falsification of ‘design theories’ (Gregor & Jones 2007)? This question cannot be answered by a positivistic epistemology which assumes a pre-defined and context independent set of categories. For instance, Hevner et al. (2004)
and Zimmerman (2007) assume that models and theories can be generated which describe the interaction of humans and IT artefacts in a reproducible, design-oriented manner. So, design practice applies (and empirically validates), in this view, a set of models and theories to create innovative IT artefacts with regard to specific contexts.

An alternative view was outlined by Peirce’s considerations about abductive reasoning which suggests building explanatory, sensitizing concepts from single case observations. Here, abduction could be understood to reflecting on the practical reasoning making sense of new, unknown situations and making such reasoning explicit and criticisable (Oevermann, 2001). While we do not believe in a deductive (nor, strictly speaking, inductive) paradigm in transferring design-relevant insights, we rather assume an abductive emergence of new ideas within reflective design practice (see chapter 3). Therefore, the context-sensitivity and the complexity of individual design cases need to be preserved and documented – rather than abstracted. These specific experiences stimulate designers in an abductive manner to create new IT artefacts dealing with specific problems in new contexts.

The point about design case studies is documenting individual incidents, analysing them in their highly contextualized nature, and building sensitizing concepts by aggregating and comparing. The nominal similarity between Grounded Design and abductive Grounded Theory (Reichertz, 2007) is not accidental: Grounded Design can be understood as writing a ‘grounded theory’ from design case studies by means of a comparative analysis of individual cases in their contextualized complexity. We believe that such an undertaking would be an appropriate means to support reflective practitioners and to gain design-related insights.

To identify analytic similarities within a collection of design case studies, we suggest creating bottom-up concepts by comparing individual cases. Concepts may relate to social practices in a given field of application, specific features of IT artefacts, or the fit between artefacts and practices and the artefact’s appropriation over time. Such concepts allow organizing the documentation of design case studies.

By comparing two design case studies in the domain ‘IT for the aging society’, we created the concept of grown and constructed autonomies, characterizing a specific feature of social practices (Wulf et al. 2015). This concept characterizes autonomy-related care situations by questioning given rationales in practices of care giving. The concept sensitizes empirical analysis of, and IT design for, these practices by focusing on the sometimes neglected aspects of personhood on the part of older people, and how they are positioned in the socio-cultural contexts of families and care homes. The concept of grown and constructed autonomies is an abstraction which emerged from a comparison of given care practices in two specific design case studies associated with an analysis of the related literature. Betz and Wulf (in this volume) create six conceptual dichotomies when comparing two consecutive design case studies in the domain of emergency response.

Appropriate documentation facilitates concept building across cases and the transfer of such insights to multiple audiences (practitioners, education, society). Comparing documentation across individual cases yields insights that may be orthogonal to and transcend the focus of any single case. By contrasting and comparison bottom-up concepts may emerge which from an analysis of a single case alone might appear tangential at best. However, such concepts may provide a larger perspectives and societal relevance.
Design documentation has been a central concern in research through design (e.g., Gaver 2012; Bowers 2012; Gaver and Bowers 2012; Dalsgaard and Halskov 2012). Yet, with Grounded Design we argue for two issues that have so far been neglected in this body of work:

(1) Design documentation needs to focus not on designed IT artefacts alone, but on their embedding in a particular domain of practice.

(2) Design documentation needs to focus on longer-term developments in the appropriation of IT artefacts and emergent practices of their use.

The creation of bottom-up concepts offers opportunities to analyse similarities across different studies, and thus allows us to better navigate the complexity of larger collections of documentation. Put simply, they allow the establishment of a corpus.

**Quality Criteria for Design Case Studies**

The driving forces for Grounded Design are, on the one hand, ever changing and yet to some extent stable practices and the related problems and developmental opportunities perceived by practitioners and designers. On the other hand, Grounded Design is stimulated by the emergence of new technologies in the broader field of computing. Against this background, Grounded Design finds innovative socio-technical assemblages which are explored within design case studies.

So, the question emerges how does one judge the quality of a design case study and its documentation. Or, to frame it differently, what are good research practices in a Grounded Design framework?

Design case studies are directed, on the one hand, towards the needs and desires of practitioners. From this point of view, satisfied actors whose practices have evolved towards a better quality of life are testimony to a successful project. On the other hand, these experiences and designs need to be documented and reflected as part of the academic endeavour. Such a documentation is directed towards the preservation and transfer of insights gained while designing in practice. Documentation and reflection are the core of the academic enterprise which distinguishes it from pure consultancy work by IT professionals. Traditionally, these documentations take place in the form of academic papers, which need to be directed to certain academic discourses which offer the required legitimation structures. Yet, a good academic analysis requires an in-depth engagement in practice. There can be considerable tensions between these two sets of quality criteria (Wulf et al. 2015).

Therefore, quality criteria for design case studies must relate to their different foci and activities: the study of social practices, the IT design (including the design process and designed IT artefact), and the appropriation of the IT artefact in use. These aspects require adequate documentation and analysis to facilitate knowledge gains. We elaborate on quality criteria for each aspect in the following.

Good design case studies are characterized by an in-depth understanding, and descriptions, of social practices in the field of application with a specific focus on how these empirical findings may contribute to the design of IT artefacts. The quality of the understanding is not necessarily only related to the length of the empirical context study but also the complexity of the practices, and to the sensitivity and (field-specific) experience of the researchers and the (temporal) resources and willingness of the different practitioners to participate in the research endeavour. While IT design cannot be deduced
directly from empirical data (Dourish 2006), these findings ground the IT design. Their quality is therefore essential for the research endeavour. A highly valuable genre of empirical analysis may also question the validity of a particular IT artefact or of a certain approach to the design of IT artefacts - e.g., empirical insights into the inadequacy of certain IT artefacts for the practices of fire fighters (Ramirez et al, 2012).

With regard to the IT design, the central quality criterion is its fit with the social practices to be supported. It is not so much about high-tech, then, but about high-value. A good example is Facebook: From the traditional applied computer science stance, Facebook just presents an ordinary distributed system. Still, with regard to social impact, Facebook and how it is appropriated present a very interesting design case (Rohde and Wulf 2011).

The quality of an artefact’s appropriation needs to be investigated empirically for two reasons: First, to uncover what practices are affected by the design in the wild, and second to reflect and judge about effects from the various standpoints of the stakeholder. For instance, from a user perspective eco-feedback might be judged as positive because it makes electricity consumption more visible - while from a society perspective the technology is judged as a failure as it does not lead to the expected electricity saving (Schwartz et al. 2014). In sum, the final evaluation is carried out in practice. However, an analysis of the design process itself and the resulting IT artefacts can additionally yield valuable insights.

With regard to the design process, it can consist of a long term highly participatory engagement, like for instance, in the case of the design of navigation and communication support for fire fighters (cf. Ramirez et al. 2012; Betz and Wulf, in this volume). At the other extreme, it may just consist of selecting and tailoring an already existing IT artefact. A longer term design process can explore the design space systematically and reveal additional insights into the alignment of practices with specific design options.

With regard to the IT artefact, an obvious quality criterion is innovativeness, firstly, with regard to the technological state of the art or, secondly, with regard to an artefact’s specific configuration for a certain field of application. In any case, there is a trade-off between the potential impact of the technological innovation and support for the relevant social practices. The point here is that a practice-based design paradigm takes this tension very seriously and seeks to find some balance in and through reflection with stakeholders. It is often technologically quite straightforward to realize an artefact which offers interesting opportunities to support practices. In the case of a sewage work company, we extended a given document management system with two rather simple tools to add metadata in a semi-automated manner. This way the existing technical drawings could be searched much more efficiently when the street channels were to be maintained (Hinrichs et al 2005). Additionally, the reuse of given (tailorable) artefacts in new contexts should be considered an important research direction since it provides us with a better understanding of socio-technical fit.

With regard to investigation into appropriation, high quality research offers long term, in-depth, and honest empirical observation of the way the use of artefacts changes the related social practice over time. In this sense, it does not matter whether the introduction of the IT artefact affords changes in social practice which were anticipated during IT design. We would argue that the most interesting results emerging in this phase are those associated with non-anticipated appropriation moves (Orlikowski 1996, Pipek and Wulf 1999 and 2009, cf. Stevens and Pipek, this volume).
A longer term research approach is highly desirable since practices do not evolve in an instant, but rather need a longer period of time. It is highly desirable to describe how the changes in practices were brought about and how individual learning provides, in time, new collective insights and new artefact use. To better understand appropriation, it is very important to document how the appropriation of the IT artefact has been supported by the research team.

As already indicated, the documentation and analysis of design case studies is directed towards comparison, concept building, and the transfer of insights to similar settings but, more ambitiously to related but never identical domains of application. Therefore, the analysis of design case studies along all three activities discussed in section 4 needs grounding in, and a comparison with, related work. A practice-oriented paradigm needs particular emphasis when considering the state of the art. The aim is not to subsume the particular case under pre-defined categories, but understand the common issues, but also the particularities of the case by comparing what we know from literature and other cases. Since all design case studies are deeply shaped by the social context they are happening in, it requires a sensitive description and treatment of the setting.

A practice-oriented design paradigm in academia favours in-depth exploration and cross-comparison. Insights are generated and validated by investigating into similar domains of practice as well as by introducing similar or even the same IT artefacts into different practices. Such an approach facilitates concept building through comparison and studying the fit of IT artefacts across similar settings or fields of practice. Of course, what is similar, and how it is to be construed (and by whom) is a non-trivial problem.

A valuable design case study does not need to be equally well worked out with regard to all of the quality dimensions discussed above. There can be a myriad of reasons, often emerging from specificities in the field(s) of practice as well as from the ongoing design practice, for specific limitations (see section 4). Most important is the coherence of the different research activities.

**Sharing Knowledge in the Grounded Design Paradigm**

How can experiences gained in highly contextualized design case studies be made relevant and applicable beyond their specific setting? This question is closely related to the analytic issues associated with single case studies, but focus more on how we encourage the transferability of insights in a non-positivist design research paradigm. While IT designers gain their rich experience in practice, the question emerges how to transfer these insights beyond individuals and their respective communities of practice. Structurally similar problems of transferring specific insights have already been widely discussed in knowledge management and, of more interest to us, knowledge sharing (Ackerman et al. 2002 and 2013). To support knowledge sharing, these authors suggest that we need to focus on innovative and flexible assemblages of materials and actors (e.g. Pipek et al. 2012).

In sharing design relevant knowledge, we can imagine different community structures and cross-community learning processes, for instance: Within the local context sharing knowledge inside the design team working on the same project or among design teams working on related project. Within the academic context, focusing on related cases, but also among the academic community working in the broader fields of human-centred computing or the academic community educating future design prac-
titioners and researchers. Within the commercial setting, between academic designers and IT designers of between academic designers and actors who want to apply given IT artefacts in different fields of application.

For each of these constellations of knowledge sharing, we need different level of reflection, making the particular contexts and insights understandable. With regard to the audience, we need to cater for assemblages of appropriate materials and actors. For instance, in the academic context, the degree of explicitness is typically higher, on the assumption that the interpretations arrived at can and should be proofed and/or subjected to critique. In contrast, practitioners may be less theoretically or conceptually motivated, but desire a summary of lessoned learned and how this knowledge could be applied to solve the problems at hand. While knowledge sharing in some of these constellations happens during the design process, others span a longer period of time and may, therefore, require different approaches to documenting insights.

Practices of design-related knowledge sharing, and the forms of documentation that prove workable solutions, have not yet been investigated to any systematic degree in any of these constellations. So far, we have (to some degree) standardized formats to document knowledge within academic communities but they are arguably singularly inappropriate for use in more commercial environments. In the field of human-centred computing, the academic practice of documenting insights mainly draws on conference and journal papers – describing aspects of the IT artefacts and the design process and practice. While, for instance, the ACM Digital Library also allows uploading additional material such as videos or source code, IT artefacts or additional empirical data are rarely made accessible. The link with the academic design practitioners is typically provided by the authors’ published work. However, sharing design-related knowledge is, even within the community of researchers in the field of human-centred computing, not yet well understood and supported. Moreover, academic papers may not be the best means to communicate design-related insights – specifically not for practitioners. Many aspects of knowledge sharing within other epistemic communities or cross-community linkages need further investigation. Overall, one may argue that the IT design community has not yet been very successful in knowledge sharing.

So, there is a considerable challenge to support knowledge sharing in the way we suggest. In discussing opportunities for knowledge building, Gaver (2012) and Gaver and Bowers (2012) suggest documenting IT artefacts created by a design studio by means of a portfolio which compares and discusses individual instances. In addition, Gaver and his colleagues make use of YouTube to provide vignettes about the appropriation of artefacts that illustrates possible futures of digital interior design\(^2\). Höök and Löwgren (2012) suggest synthesising the core design idea behind a range of IT artefacts into a design concept through processes of reflection, analysis, and articulation. These steps, however, do not reflect the relationship with practices that we are most concerned with (see chapter 4). Therefore, we need to find new ways of documenting design-relevant insights – thinking about the preservation of IT artefacts, empirical data, and their structuration in a new manner.

\(^2\) Cf: TheCuriousHome https://www.youtube.com/channel/UCHtJoZYHOv4UvW_Htn-BGkA (12/9/2016)
Building a Portfolio of Design Case Studies

We believe that collections of design case studies should be documented and presented in layered portfolios. The different layers would allow for different granularities of access to the basic materials and actors according to the types of audiences insights are intended to be shared with. While the layers are based on the same basic design case, they need to be created specifically for different audiences – e.g., academia, practitioners, and students in varying social arrangements (see listing in chapter 6 of this paper). Such documentation is both a challenge and an extra burden for those working in this emerging (academic) design culture.

The most basic layer of portfolios should support the design work within the project team and document some of it. It should allow for the sharing of empirical (raw) data such as audio recordings and transcriptions of interviews, field notes, or field diaries as well as analytic categories or coding schemas. It should document the design process allowing to allow sharing of emerging technical designs such as scribbles, mock-ups, prototypes, and running system versions. Of special interest is the linkage between empirically analysed practices, participatory design processes, resulting design ideas, and the appropriation of designed artefacts over time. The goal is to document the evolving analytic and creative work that lead to different aspects of a designed artefact.

One can consider good design practice to involve the sharing of such data within cross-disciplinary design teams, especially in the context of heterogeneous institutional interests, to shape a coherent project vision. However, this raises questions about the ownership, not just of the data, but also about the interpretation. In particular, single case, abductive reasoning is often characterized by the fact that various interpretations are possible. This raises the question, who has the authority to deliver a final opinion and how to deal with conflicting interpretations. Depending on the institutional divides and the degree of mutual trust within a design team, certain techniques of information hiding, for instance, in the sense of anonymization of sources or abstraction of insights, may need to be applied. IT companies, being part of the design team, may also hide some of their results due to issues relating to intellectual property rights and commercial product development.

At a next layer, it is beneficial to compare the results of different teams working in the framework of Grounded Design. Here, emerging bottom-up concepts may evolve into an additional dimension to navigate through design cases. We have conducted such comparative analysis so far in two ways:

(1) We compared historical design case studies among themselves or with currently running ones. However, each historic design case study was at least represented by one member of the design team (Wulf et al. 2015; Betz, in this volume).

(2) We compared across concurrently running projects. To this end, we set up workshops in which the different researchers explained what they did and which results they found most remarkable.

Both approaches did not draw very much on design-relevant data documented in portfolios because we do not yet possess a rich and well-structured documentation of our design efforts. So, the analysis drew instead on the design team member’s recollections, their articulation, some data and artefacts still at hand, and published papers. We believe that comparative analysis between design case studies
could benefit from materials shared via the portfolios – specifically in the case where the design projects are not conducted concurrently and the members of the design teams are no more available for face-to-face discussions.

In respect of academic communities, for the purpose of comparison, we need a richer description of social practices, design work, and the resulting IT artefacts that the format of conference or journal papers currently offers. Comparative conceptual work of the kind we advocate takes place only rarely and academic conferences continue to be plagued by competition among concepts rather than the evolution of agreed frameworks. Given the current paper formats of top academic venues in the HCI and CSCW community (e.g., ACM-CHI or ECSCW), a design case study currently needs to be broken up in different parts to become publishable. Where a contextual study may contain detailed empirical work, conclude with some design concerns, may include an analysis of the participatory design process focusing on procedural findings and artefact-oriented outcomes, or may be a study of the artefact’s evaluation and/or appropriation, it is difficult to provide in an adequate fashion a description of a case that incorporates all the possibly relevant facets. Individual academic papers are a poor vehicle for the systematic building of comparable cases.

With richer descriptions which reach beyond the typical academic article, design-related findings could become better accessible in a more profound and contextualized manner. For instance, being capable to play with a running system version could stimulate much better comparative analysis than one which is merely based upon the reading of selected screenshots.

The current set of academic publication formats limits the possibilities of engaging in reflective meta-analysis and comparison across cases – as exemplified by the fact that very little that looks like a corpus is currently available to the HCI community. In publications, one dominant narrative derived from the analysis of documented empirical, design, and appropriation would arguably provide the necessary foundations. Deriving cross-cutting insights may take place on the research group or community level. The latter might show more resistance to such a radical form of openness, sharing, and possible vulnerability; the former may be more interested in deriving cross-cutting insights.

Another major challenge in sharing design related knowledge is crossing the divide between academia and practitioners. In the European context, research projects often enable (and sometimes require) the participation of IT companies and application partners inside the design team (cf. Wulf et al. 2015). Yet, the differences in design practice, organizational goals, and value systems can pose a major challenge in conducting design research under these rather short-term funding schemes (cf. Dachtera et al 2014). Co-constructing lightly structured collections of design materials as they accumulate during project runtime helps maintain a common project repository. Such a repository can build a basis for co-creating representations of design-related insights that are geared towards practitioner audiences.

Transferring design-relevant insights is an even bigger challenge in the case practitioners where have not been involved in the research project at all. Academic papers, with all their specificities of focus, may not be the best way to share knowledge in these instances. Transferring personnel or building regional networks of practice is one approach to knowledge sharing (Fischer, Rohde, and Wulf 2007) although without the conceptual foundations which would constitute a corpus, it is difficult to see how this can be done. As yet, beyond the local reach we lack a clear understanding how the sharing of design-related knowledge could be best supported and which role collections of well documented design projects could play in that.
Collections of design case studies should, at least partly, be handled via specific computer applications. These support tools can allow us to link applications to handle qualitative data, such as MaxQDA, with repositories for code sharing, such as GitHub. To document design work and share it appropriately, additional functionality needs to be developed.

We suggest that such digitalized collections of design case studies be called ePortfolios. However, such ePortfolio applications, as and when they are developed, should allow for repositories which incorporate material forms as well, such as exhibits, manuals or booklets. Bottom-up concepts could provide a potential navigation structure within ePortfolios. When selecting a concept, a description may be displayed together with a link towards the design case studies the concept emerged from. From there, further links could offer access to the different layers of documentation which provided the basis for the concept’s emergence.

Tools are required and need to be developed that support the creation of portfolios to document design case studies in adequate detail—adequate, that is, to the heterogeneous purposes we have described—and facilitate their comparison. Tools such as the ePortfolio need to plug into Grounded Design practices, practices that are highly heterogeneous and diverse. Such tools need to provide processes and scaffolds for the emergence of structures in the documentation—not precluding any form of design practice and design documentation over another. By variously enabling diverging practices of design and empirical work, tools should be aimed at two objectives: First, they should facilitate collecting materials and documenting processes in as lightly structured manner as necessary for a particular design process. Second, to foster meta-analysis across cases, tools should allow higher-order structuring of the design documentation, for instance, by flexibly allowing pathways through and interlinking of individual aspects in a body of materials. An interconnecting layer that rests on top of design documentation facilitates meta-analysis and post hoc structuring of heterogeneous materials.

Yet, no matter how well these tools are integrated into the design research process, academics and designers still need to be motivated to do the additional work of sharing their data and designs. Making available raw data as well as outcomes needs to be seen, for instance, as directly analogous to publications of data sets that can be referenced, cited, and credited when re-used and appropriated in other contexts (as is increasingly common in empirical research in the social sciences). Research valuation and career opportunities need to go along with such a change in design practices, for instance, considering the publication of data sets or case study portfolios in similar ways as research publications itself. Research standards (by funding bodies) would need to develop in that direction, as well.

A similar issue concerns the perceived disutility of complex, long-term case studies within the academic community. The current academic culture is arguably driven by quantity of paper output as much as quality. Yet, socio-technical design research is a risky endeavour, requires lots of maintenance work that is not directly related to the research outcomes, and takes a lot of time and resources. Other metrics, again, need to be developed that appreciate complex, long-term case studies, their rich documentation, and potential meta analysis and cross-comparison.

During such longer-term engagements in a particular domain of practice, problems will evolve, shift, change, vanish or emerge. The exploration of a domain of practice becomes a journey with multiple different starting points, milestones, and certainly endings. In such an evolving context the term, ‘problem’ needs to be rethought: to what degree can a set of problems be specified a priori? In how much can they be identified through a context study? To what extent is the design research process itself an
exploration of a problem space? And, how far can there ever be a definitive answer that is distilled in just a few research papers?

A certain fluidity is necessary not only for the design research process itself, but also for the presentation and communication of its findings. Staying open to interpretation is an often-iterated mantra in design research (Sengers and Gaver 2006), but it should not be in the purview of the researcher-designer alone during the design process itself. Interpretation of takeaways should be afforded during and after the conclusion of a design process for practitioners (and for wider society where relevant) as well.

A challenge for longer-term engagement with a domain of practice is how to ensure the continuation of the design intervention after the funding of the research project runs out (see also Binder et al. 2011). The limited life time of research projects typically cuts short any longer-term study of an IT artefact’s appropriation. Much worse, a limited timeframe endangers the usefulness of the artefact for the domain if processes of embedding are not given enough time and care. While researchers are ethically accountable for their interventions in a field, it is not research funding’s primary aim to cater for the practical adoption of a design innovation in a particular domain of practice. On an ethical basis, nevertheless, researchers are accountable for outcomes that extend beyond the lifetime of a project when and if participants from outside the academic environment are enlisted. To live up to such responsibilities, one approach is to build and nurture a community of practice extending beyond a single design project.

The vision of ePortfolios is to allow Grounded Design to put longer timespans to use by facilitating the comparison and contrasting not only of different but related design case studies, but also of a succession of consecutive research projects. The ePortfolio should facilitates design research trajectories that last longer than a single project’s lifespan or the engagement of individual researchers, tackling difficult societal issues and concerns that are slow to change (see also Friedman et al. 2016). In this respect, the ePortfolio is a technique to grounding design in the past (practices), but towards shaping long(er)-term socio-technical futures.

**Conclusion**

The Grounded Design paradigm suggests an orientation of the computing field towards understanding the relationship between specific settings and wider conceptions of the domain more clearly. Understanding, and designing for, problem issues in work contexts as well as public issues in a wider societal context requires procedures for establishing ‘boundary relevance’. Just how far, that is, can the procedures we outline take us in terms of scoping and limiting possibilities? Grounded Design, we argue, provides a socio-technical approach for the solution of social issues in context. It builds on a practice-based and constructivist (rather than positivist) paradigm, seeking to study emerging and evolving practices of use over longer periods of time after new IT artefacts have been designed and introduced. In that sense, Grounded Design suggests a praxeological turn in the field of computing.

Two driving forces nurture such an approach: (1) supporting evolving practices and evolving social challenges and (2) new (basic) technological opportunities that may be employed to such ends. Grounded Design explores new technological opportunities in the context of a certain domain of practice and its challenges to study the novel technology’s fit with, and impact on, actual local practices over time.
By studying appropriation of an IT artefact over time, Grounded Design is able to understand the transformation and fitting between (newly) designed artefact, certain practices, and the context of use (cf. Stevens & Pipek, this volume). This leads to insights about practices of use that degrade, change or evolve in ways unexpected and surprising to the designer. Such insights about IT appropriation and changing practices of use are crucial for the (re-)design of IT artefacts. These are insights that often remain opaque with other approaches but fundamentally impact the design of future IT artefacts.

A key concern within a Grounded Design paradigm is to ensure transferability of the rich yet local and context-specific design knowledge that emerges with such an approach. To ensure transferability, we propose conducting design case studies in various domains of practice. Design case studies, as we have suggested, consist of three interlocking activities appreciating the complexities of the field: (i) an empirical context study, (ii) the participatory, experimental design of (digital) artefacts, and (iii) the study of its appropriation.

We have argued that, when conducting design case studies, a key strategy to knowledge building and ensure transferability of insights is to facilitate documentation of processes and outcomes and their button-up analysis in an abductive stance. Structured documentation of design case studies allows us to preserve, make accessible, and communicate knowledge for future research and design activities and to other audiences such as practitioners or for education.

Fundamentally, with Grounded Design we propose practice-based computing as an independent field beyond the theoretical and the positivistic computer science that fosters the comparison of local, situated, and context-specific insights documented in design case studies. We imagine a research infrastructure, such as the ePortefolio, to allow for cross-comparison and meta analysis of cases in various (potentially but not necessarily related) domains of practice. Through such cross-comparison, the ePortefolio should facilitate bottom-up concept building across cases. The emerging concepts then scaffold navigating the empirical materials across cases and for drilling down to the empirically rich particulars. Thus interlinking situated design knowledge through emerging concepts in an IT environment such as ePortefolio, an experience and knowledge base emerges for transferring insights to other domains of IT design and practice as well as for other audiences.

Comparative analysis of this kind makes the research context and associated interventions in the field more and better understandable and improves their communicative quality. Portfolios of design case studies provide an additional layer of communication of knowledge that can be geared towards different audiences, and which can relate directly to empirical and design materials.

From our point of view, a practice-based paradigm, such as Grounded Design, needs to be complemented with an approach to meta research into its own design practices. Since Grounded Design explores and intervenes into the given social practices of its fields of application, this research practice needs to be documented and analysed – at least in selected case studies. Meta research strengthens researchers’ self-reflectivity and a comparative analysis may result in a better transferability of insights. Finally, meta research can ground the design of IT tools in support of practice-based research, tools such as the ePortefolio (see Randall et al, in this volume).

Grounded Design as a new paradigm for applied computer science comes with a normative positioning. It seeks to make the voices of practitioners heard and relevant to future developments. It engages in, broadly, the ethnography of often invisible aspects of life and work and in the participatory design with and for practitioners in order to improve certain practices. That is, Grounded Design engages with
social and societal challenges on both small and large scales. Grounded Design takes seriously computing’s increasing societal relevance in all aspects of life.

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