Design Thinking for the Twenty-First Century Organization

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1 How Does Organizational Mismatch Impact Design Thinking and Innovation?

Given

"Team of teams" organizations are good for innovation.
"Command-Control" organizations are good for efficiency.

Grand Challenge

How does one interface these highly disparate organizations to preserve and promote collective creativity?

The probability of breakthrough innovation has increased as we gain a deeper understanding of design innovation processes and the organizations that use them best. It is increasingly clear that an organizational "impedance mismatch" is a barrier to bringing breakthrough innovation home to corporations, governments, and economies.

A brief working definition of **"impedance mismatch"** is that which inhibits the movement of electrons, protons, money, and ideas. We include especially the inhibition of free flowing human communication and creative experimentation.

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Design research has begun to tackle this issue with new metrics and heightened awareness of organizational structure as a core barrier to growth through innovation.

Discovered

A "team of teams" organization is good for design thinking and breakthrough innovation.

The industry sponsored engineering design project course at Stanford University, ME310-Global, has evolved over the past 30 years to function as a global team of teams. Companies bring engineering design-innovation challenges to the course each year with project briefs that typically take the form "re-invent X."

As the curriculum evolved, the traditional notion of isolated teams working on "design challenges" gave way to evidence that teams helping each other across design challenges, corporate identities, and personal relationships were outperforming locally insular teams. And then the curriculum began to "spin-off" to other universities and their networks of companies and colleagues. In time the outer constellation of industry sponsored design-X challenges became known as the SUGAR Network. An imaginative visualization of the network, Fig. 1, has become an iconic representation of a human-centric breakthrough innovation challenged team of teams. Two different academic teams of 3–4 graduate students at

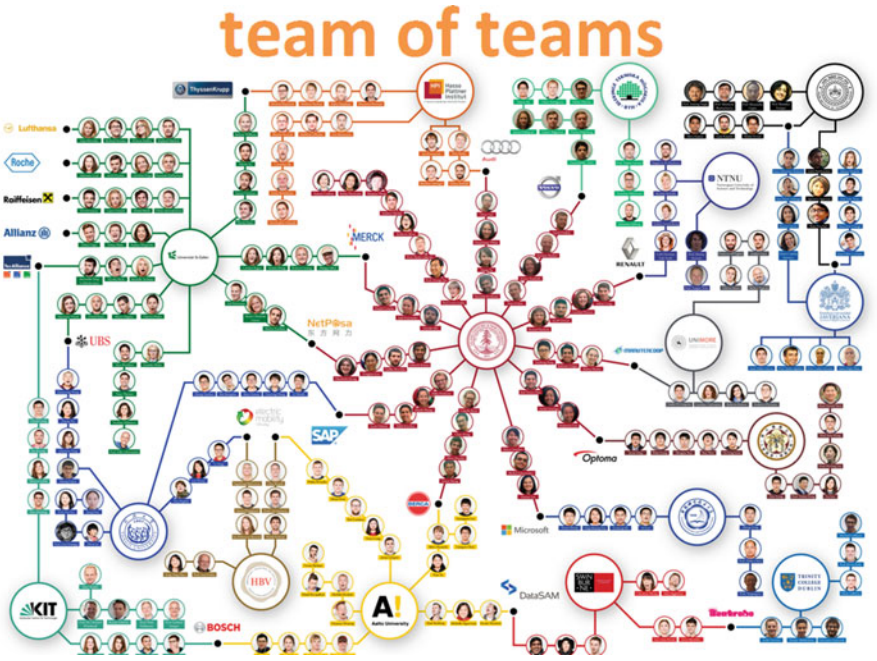

Fig. 1 The 310-SUGAR Network (2014–2015) is an academic-industry team of teams in open association of students, faculty, and corporate representatives driven to deliver breakthrough innovation for business defined design challenges

internationally dispersed universities own each project. The university constellation is aided by corporate teams of 3–4 people to further the reach and depth of the team of teams.

The Hasso Plattner Institute (HPI) is a leading member of the network with outreach to its many global initiatives.

Defining characteristics of the twenty-first century innovation ecosystem include the following (after Dorst 2015). How might we help corporations, universities, and societies to accelerate innovation in ways that keep pace with these challenges?

OPEN: unbound systems
COMPLEXITY: systems of system elements and relationships
DYNAMIC: change with diminished element and process half-life
NETWORKED: across organizational elements and relationships

Looking across the abyss between the innovation oriented team of teams towards the efficiency oriented command-control organization we speculate that one needs to see an "intrapreneur" in corporate structure. Speculating further, we hypothesize that the insider intrapreneur needs to be part of an insider "team-of-intrapreneur-teams." The impedance mismatch needs to be matched to an augmented flow structure. This scenario has been forecast by Beth Altringer, November 2013, in her Harvard Business Review article "A New Model for Innovation in Big Companies."

In Altringer's paper she reports that "Studies show that efforts to stimulate intrapreneurship—entrepreneurship within an established company—more often than not fall flat. According to my current research at Harvard on innovation models in global companies across diverse sectors, these types of projects fail between 70 % and 90 % of the time."

Is it time to formalize the role of institutional intrapreneurs?

A formal definition of entrepreneur and entrepreneurship follows:

> **Entrepreneurship** is the process of designing, launching, and running a new business, i.e. a startup company offering a product, process or service. It has been defined as the "...capacity and willingness to develop, organize, and manage a business venture along with any of its risks in order to make a profit." The **entrepreneur** is "a person who organizes and manages any enterprise, especially a business, usually with considerable initiative and risk." "[R]ather than working as an employee, [an entrepreneur] runs a small business and assumes all the risk and reward of a given business venture, idea, or good or service offered for sale. The entrepreneur is commonly seen as a business leader and innovator of new ideas and business processes."
>
> Entrepreneurs perceive new business opportunities and they often exhibit positive biases in their perception (i.e., a bias towards finding new possibilities and unmet market needs) and a pro-risk-taking attitude that makes them more likely to exploit the opportunity. "Entrepreneurial spirit is characterized by innovation and risk-taking".[1]

[1] https://en.wikipedia.org/wiki/Entrepreneurship

Intrapreneurship is the act of behaving like an entrepreneur while working within a large organization. Intrapreneurship is known as the practice of a corporate management style that integrates risk-taking and innovation approaches, as well as the reward and motivational techniques, that are more traditionally thought of as being the province of entrepreneurship.

Pinchot (1984) defined intrapreneurs as "dreamers who do. Those who take hands-on responsibility for creating innovation of any kind, within a business". In 1992, *The American Heritage Dictionary* acknowledged the popular use of a new word, intrapreneur, to mean "A person within a large corporation who takes direct responsibility for turning an idea into a profitable finished product through assertive risk-taking and innovation". Koch (2014) goes further, claiming that intrapreneurs are the "secret weapon" of the business world. Based on these definitions, being an intrapreneur is considered to be beneficial for both intrapreneurs and large organisations. Companies support intrapreneurs with finance and access to corporate resources, while intrapreneurs create innovation for companies.

The intrapreneur is not to be confused with the "innerpreneur", a person who aims at personal fulfilment more than at economic gains when creating a business.[2]

The intrapreneur is driven by most of the same beliefs as the entrepreneur ("there has to be a better way"). Unlike the typical "outsider" entrepreneur, the intrapreneur is part of the organization. There is even a case for the "Chief Intrapreneur", but this title goes against the team of teams organization's values and methods. Perhaps the intrapreneur is chief of the bottom-up brigade; more of an inspiration than a chief.

Institutionalizing the intrapreneur is a move forward with the professionalization of design thinking. Imagine a pan-disciplinary doctoral program for understanding intrapreneurship as design thinking within institutional practice. There is movement in this direction at Stanford University and the Hasso Plattner Institute in Potsdam. The international SUGAR Network and the HPI network of d.schools are both well positioned to implement intrapreneurship training, practice, and needed research.

Once again, the design-paradigm is worth your attention.

We continue to improve our understanding of design thinking, to discover impactful practices, and to disseminate these practices through publications, simulations, emulations, and workshops. The understanding we derive from the study of human teamwork with IT augmentation is, again, foundational.

2 The HPI-Stanford Design Thinking Research Program

With the progressive dissemination of design thinking in practice, education, and academia over the last years, the demand to understand this method has increased. Already back in 2008 the joint HPI-Stanford Design Thinking Research Program was established, funded by the Hasso Plattner Foundation. Within this program,

[2] https://en.wikipedia.org/wiki/Intrapreneurship

scientists from the Hasso Plattner Institute for Software Systems Engineering in Potsdam, Germany, and from Stanford University, USA, strive to gain a deep understanding of the underlying principles of design thinking and, consequently, how and why this innovation method succeeds or fails.

2.1 Program Vision and Goals

Multidisciplinary research teams from HPI and Stanford with backgrounds in disciplines such as engineering, design, humanities or social sciences scientifically investigate innovation and design thinking in all its holistic dimensions. These areas include technical, economic, and human factors. Applying rigorous academic methods, the researchers examine how the innovative process can be improved and further developed.

The program pursues the goal to advance design thinking theory and knowledge within the research community and ultimately improve design practice and education by gathering scientific evidence to support design activities. Beyond a mere descriptive understanding, this program aims, for example, to develop metrics that allow assessment and prediction of team performance to facilitate real-time management of how teams work. Scientists study the complex interaction between members of multi-disciplinary teams, with special regard to the necessity of creative collaboration across spatial, temporal, and cultural boundaries. They design, develop, and evaluate innovative tools and methods that support teams in their creative work. The projects pursue the common questions of why structures of successful design thinking teams differ substantially from traditional corporate structures and how design thinking methods mesh with traditional engineering and management approaches.

Researchers are especially encouraged to develop ambitious, long-term explorative projects that integrate technical, economical, as well as psychological points of view using design thinking tools and methods. Field studies in real business environments are considered especially important to assess the impact of design thinking in organizations and if any transformations of the approach may be warranted.

Special interest lies in the following guiding questions:

- What are people really thinking and doing when they are engaged in creative design innovation?
- How can new frameworks, tools, systems, and methods augment, capture, and reuse successful practices?
- What is the impact of design thinking on human, business, and technology performance?
- How do the tools, systems, and methods really work to create the right innovation at the right time? How do they fail?

Over the past years dozens of research projects have been conducted, our understanding of this field has advanced and new insights and tools have become available. These findings are not only meant to be discussed within the scientific community. With this book they are made known to the public at large and to all who want and need to drive innovation, be it in companies or society.

2.2 Road Map Through This Book

In the seventh program year scientists from HPI and Stanford University have again conducted various research projects on design thinking. Their results are compiled in this book, divided into four sections that illustrate the numerous facets of design thinking.

Design thinking is adopted by more and more people and organizations—in diverse and individual ways. Part 1 "***Design Thinking in Practice***" takes a closer look at how this method is applied in organizations and how it impacts them (e.g., with regard to team interactions or management). Furthermore, a tool is presented that accurately describes how design thinking is applied. The different characteristics of design thinking and what they mean are important to know for practitioners and have therefore been investigated and described, too. The last chapter explores how spaces for innovation teams are created in organizations.

With the technological progress, new opportunities as well as challenges in design processes arise. Therefore, "***Exploring Human-Technology Interaction***" stands in the focus of the book's second part. How new mobile computing devices are able to influence behavior change is examined in the first chapter, which illustrates an application of design thinking in healthcare. With *Tele-Board Med* researchers not only developed a medical documentation system and collaborative eHealth application but also investigated the impact of such a tool on team interactions and feelings. This was done specifically in a therapy context. Furthermore, in three studies researchers describe an embodied design improvisation methodology that is effective in designing the behaviors and interfaces of autonomous vehicles. They thereby look closer at the conceptual phase of design thinking as well as prototyping.

The third part of the book dives deeper into the "***Prototyping***" phase of design thinking. It explores how technical novices can be supported in electronics prototyping. In addition, research also investigates prototyping possibilities in programming, introducing a tool that increases tangibility. Finally, one project provides us insights into the development process in software companies and presents an overview of current practices concerning end-user involvement and prototyping.

The last part of the book is about "***Developing Design Thinking Teaching and Coaching Tools and Approaches.***" Special emphasis is placed on online approaches: researchers investigate whether and how MOOCs are suited for design thinking education. Furthermore, scientists demonstrate how large classes can

leverage their scale to encourage mastery through rapid feedback and revision. Projects also address "analogue" team work, providing specific diagnostic instruments based on a visual notation for augmenting design team performance. Finally, researchers investigate the underlying neurocognitive foundation and sustainability of creative capacity enhancement.

2.3 Part I: Design Thinking in Practice

In "**Colliding Influences—When Self-Organizing Teams Encounter Strategic Objectives and Established Routines**" Holger Rhinow and Christoph Meinel illustrate findings from a case study on the impact of design thinking within a large organization. As several teams begin to apply design thinking as a framework for product discovery and development, a growing influence of self-organizing teamwork and the user as a source of inspiration becomes apparent. This stands in contrast to other frameworks for product development within the organization (e.g. Waterfall and Scrum). These new influential factors are to some extent seemingly in collision with other existing influential factors, such as established routines in project management and a corporate strategy. This case study empirically clarifies the impression from previous research that the integration of design thinking appears to be a managerial challenge yet to be mastered.

With the ongoing dissemination of design thinking it is critical to develop tools that accurately describe how the method is being applied in teams and across an organization as a whole. In "**Mapping and Measuring Applications of Design Thinking in Organizations**" Adam Royalty and Bernard Roth introduce two tools in development to meet these goals. The first is an "ecology mapping" that portrays an organization's internal design thinking strategy. The second is a weekly "snapshot" of design thinking activities performed by industry teams working on creative projects.

The design thinking methodology suggests a repertoire of design phases, design activities, and design methods that can be used to solve wicked problems in terms of innovative solutions. However, since it does not prescribe any order of design phases, activities and techniques, their applications lead to different shapes of the design thinking methodology in practice. The authors of "**The Design Thinking Methodology at Work: Capturing and Understanding the Interplay of Methods and Techniques**", Thomas Beyhl and Holger Giese, hypothesize that these shapes of design thinking at work consist of different characteristics depending on the kind of design project that has been conducted. Understanding these characteristics, their influence on the design flow itself, as well as their impact on the outcome of the design project is of major interest to managers, innovators, and researchers. The article reports on the result of a case study that has been conducted to investigate different shapes of the design thinking methodology in practice.

With "**On Creating Workspaces for a Team of Teams—Learnings from a Case Study**" Marie Klooker, Stephan Matzdorf, Claudia Nicolai, Lilith Böttcher, Arne Trost, and Karen von Schmieden offer first insights into defining strategic intent for the development of so-called creative workspaces. On an academic level, previous research has mostly focused on established physical environmental structures, disregarding the contextual level of strategic intent. On a practical level, companies too often copy best practice examples of other innovation labs. Based on the qualitative case study of an organization currently implementing an innovation lab, this chapter introduces a collection of categories defining strategic intent preceding the establishment of innovation laboratories within an organization.

2.4 Part II: Exploring Human-Technology Interaction

In "**Design Thinking in Health IT Systems Engineering: The Role of Wearable Mobile Computing for Distributed Care**" Lauren Aquino Shluzas, Gabriel Aldaz, David Pickham, and Larry Leifer examine the capabilities and boundaries of a hands-free mobile augmented reality (AR) system for distributed healthcare. They use a developer version of the Google Glass™ head-mounted display (HMD) to develop software applications to enable remote connectivity in the healthcare field, and to characterize system usage, data integration, and data visualization capabilities. In this chapter they summarize findings from the assessment of the SnapCap System for chronic wound photography, and present a pilot study. This work contributes to the future implementation of new features aimed at enhancing the documentation and assessment of chronic wounds. It provides insight into the need for future IT systems engineering projects with the goal of improving healthcare connectivity for distributed care.

The path to a satisfying health care outcome is manifold, and the quality of the relationship between patient and health care provider is an impactful factor. In "**Redesigning Medical Encounters with Tele-Board MED**" Anja Perlich, Julia von Thienen, Matthias Wenzel, and Christoph Meinel discuss different models for the classification of patient-provider interaction as well as for patient empowerment. On this theoretical basis, they elaborate how patient-provider interaction can be enhanced in practice by means of the medical documentation system—Tele-Board MED. It is a collaborative eHealth application designed to support the interaction between patient and provider in clinical encounters. Simultaneously, it aims at making case documentation more efficient for providers and more valuable for patients. As a research paradigm, the Tele-Board MED project has used a design thinking approach to understand and support fundamental stakeholder needs. Psychotherapy has been chosen as a first field of application for Tele-Board MED research and interventions. This chapter shares insights and findings from empathizing with users, defining a point of view, ideating, and testing prototypes.

David Sirkin, Brian Mok, Sonia Baltodano, Dirk Rothenbücher, Srinath Sibi, David Miller, Jamy Li, Nikolas Martelaro, Nikhil Gowda, and Wendy Ju have

developed a generative, improvisational and experimental approach to the design of expressive everyday objects, such as mechanical ottomans, emotive dresser drawers and roving trash barrels. They have found that the embodied design improvisation methodology has also been effective in designing the behaviors and interfaces of another kind of robot: the autonomous vehicle. "**Embodied Design Improvisation for Autonomous Vehicles**" describes their application of this design approach in developing and deploying three studies of autonomous vehicle interfaces and behaviors. Each study suggests design principles to guide further development.

2.5 Part III: Prototyping

Can anyone make a smart device? Affordable sensors, actuators, and novice microcomputer toolkits are the building blocks of the field we refer to as Creative Computing. With the growing maker movement, more tools are becoming available to novices, but there is little research into the usability evaluation of these toolkits. In "**Can Anyone Make a Smart Device?: Evaluating the Usability of a Prototyping Toolkit for Creative Computing**" Joel Sadler, Lauren Aquino Shluzas, Paulo Blikstein, and Sakti Srivastava discuss the importance of closing the gap between idea and prototype, the need for systematically evaluating the usability of novice toolkits, and a strategy for doing so. This work aims to contribute to the idea of "making simple things simple, and complex things possible," with prototyping toolkits of the future.

In "**Making Examples Tangible: Tool Building for Program Comprehension**" Marcel Taeumel and Robert Hirschfeld investigate prototyping in software engineering. Existing tools for program exploration are tailored to general programming language concepts instead of domain-specific characteristics and programmers' present system knowledge. In this chapter, the authors motivate the need for adapting the programming tools in use when navigating, viewing, and collecting examples to increase tangibility—that is, the clarity of a concept or idea based on what can be experienced on screen. In this context they present their Vivide tool building environment.

Appealing user interfaces and excellent usability are the keys to successful software products and services. However, great usability and user experience are not easy to develop because traditionally system engineers design solutions without involving end users. At the same time, current research suggests the involvement of end users in software development and the constant incorporation of testing and feedback to provide high-quality software and satisfying usability. In "**Case Studies on End-User Engagement and Prototyping During Software Development—An Overview of Current Practices in the IT Industry**" Franziska Häger, Sebastian Meyer, and Matthias Uflacker provide a look into the development process of three major software companies and present an overview of their current practices concerning end-user involvement and prototyping.

2.6 Part IV: Developing Design Thinking Teaching and Coaching Tools and Approaches

Design thinking has arguably become a state-of-the-art innovation methodology leading to an increasing demand for design thinking education. In "**Design Thinking At Scale: A Report on Best Practices of Online Courses**" Mana Taheri, Thomas Unterholzer, and Christoph Meinel aim to answer the question of whether and how design thinking can be taught in a form of Massive Open Online Courses (MOOCs), which deliver the promise of scalable teaching. In this chapter the authors discuss the opportunities as well as challenges in teaching design thinking in a MOOC environment. They propose recommendations for course designers, report on results of interviews with course instructors of the Stanford d.school on challenges and potentials of a digital design thinking learning environment, and present the path of future research.

When students work with peers, they learn more actively, build richer knowledge structures, and connect material to their lives. However, not every peer learning experience online sees successful adoption. In "**Designing Scalable and Sustainable Peer Interactions Online**" Chinmay Kulkarni, Yasmine Kotturi, Michael S. Bernstein, and Scott Klemmer first introduce PeerStudio, an assessment platform that leverages the large number of students' peers in online classes to enable rapid feedback on in-progress work. They then articulate and address three adoption and implementation challenges for peer learning platforms such as PeerStudio. They illustrate these challenges through their study of 8500 students' usage of PeerStudio and another peer learning platform: Talkabout. This research demonstrates how large classes can leverage their scale to encourage mastery through rapid feedback and revision, and suggests "secret ingredients" on making such peer interactions sustainable at scale.

Multidisciplinary teamwork is a key requirement in the design thinking approach to innovation. Previous research has shown that team coaching is an effective way to improve team performance. However, the tools currently available for effective team coaching are limited to heuristics derived from either experienced design thinking professionals or clinical psychology practitioners. The research of Neeraj Sonalkar, Ade Mabogunje, Halsey Hoster and Bernard Roth aims to improve this situation by providing design thinking managers, coaches, and instructors with a reliable instrument for measuring design team performance. In "**Developing Instrumentation for Design Thinking Team Performance**" they present the underlying methodology for instrument design. The development of a specific diagnostic instrument, based on a visual notation called the Interaction Dynamics Notation, is explained in terms of both the workflow of data through the instrument and the exploratory studies conducted to design the instrument user interface.

Additionally, in "**Stethoscopy for Design Teams: Instruments for the Exploration of Design Conversations**" Axel Menning, Andrea Scheer and Claudia Nicolai introduce two complementary instruments, the Knowledge Handling

Notation (KHN) and the Topic Markup Scheme (TMS). These instruments identify and analyze content-related and conversational patterns in team interactions. Both will be introduced and applied to a design conversation in an innovation team. TMS describes move-to-move coherence and global coherence. KHN describes on the move-to-move level how innovation teams generate and share knowledge. The output of both instruments, in the form of strings of symbols, can be used for sequence analysis and pattern detection of team dynamics. Together, the outcomes nurture the understanding of knowledge creation in and through design conversations in innovation teams.

The ability to produce novel yet appropriate (or useful) outcomes is broadly defined as creativity. So far, however, several methodological issues have restricted researchers in uncovering the brain basis for creativity and previous neuroimaging studies have for the most part produced varied findings, with little overlap. To partly mitigate some of these issues, the authors of the last chapter have recently developed a novel game-like and creativity-conducive neuroimaging paradigm that was employed to assess neural correlates of spontaneous improvisation and figural creativity in healthy adults. In "**Developing Novel Neuroimaging Paradigm to Assess Neural Correlates of Improvisation and Creative Thinking Using fMRI**" Manish Saggar, Lindsay C. Chromik, Adam Royalty, Grace Hawthorne, and Allan L. Reiss provide a brief overview of the current state of neuroscience research focused on creativity. They also provide insights regarding their experimental design, challenges faced during prototyping as well as a summary of their results. Lastly, building upon their novel paradigm, they provide pointers to future work for assessing neural correlates of creative capacity enhancement and team creativity.

2.7 Outlook

The publication at hand is the seventh of a series about Design Thinking Research and continues to share the findings from our HPI-Stanford Design Thinking Research Program with the public. We are pleased about the extension of this program for another 6 years that allows us to continue our work for a better understanding of design thinking, to investigate and develop tools and methods. As always, we are delighted to share and discuss our findings—not just with this and previous books but also through many other channels that have been established over the past years.

A very recent platform is thisisdesignthinking.net, a website that was launched by a project team of the Design Thinking Research Program. With the design thinking-related case studies and interviews presented there, enriched with scientific explanations, the researchers from the Hasso Plattner Institute provide insights from years of studying the application of design thinking in practice. This website is intended to serve as a pool of shared experiences from practitioners, scientists and coaches. It thereby presents the manifold perspectives on design thinking and meets

the demand from practitioners, managers, entrepreneurs, and employees for more information about the application of this innovation approach. In the following chapter, the authors introduce this project and invite you to share your experiences on the website as well.

Furthermore, the Electronic Colloquium on Design Thinking Research (ECDTR, http://ecdtr.hpi.de) is an online forum using electronic media for scientific communication and discussions in the design thinking research community. It is ideal for the rapid and widespread exchange of ideas, methods, and results in design thinking research and welcomes papers, short articles and surveys.

To learn more about our Design Thinking Research Program we invite you to visit our website www.hpi.de/dtrp. It presents the latest information on past and present research projects, activities, publications, and community members.

We thank all authors for their contributions to this publication. Special thanks go to Dr. Sharon Nemeth for reviewing and copyediting them, as well as to Claudia Koch for preparing and coordinating the publication. Above all, we are grateful to Hasso Plattner for his constant support for our research and the extension of the Design Thinking Research Program for another 6 years. Over the past research years, meaningful knowledge about design thinking has been gained, yet so many more questions still remain unanswered. The field of research is broad, the demand for further insights both from academia and practice is rising. We are looking forward to continuing our work, expanding our knowledge about design thinking and sharing it with the public. This is our contribution to drive innovation in companies and society. We would be pleased to engage in dialogue with our readers for further discussions about your ideas, experiences, insights and questions via one of the above mentioned channels.

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