The Open Paradigm in Design Research

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1   See, e.g., Henry Chesbrough, "Open Innovation: A New Paradigm for Understanding Industrial Innovation," in *Open Innovation: Researching a New Paradigm*, ed. Henry Chesbrough, Wim Vanhaverbeke, Joel West, (Oxford: Oxford University Press, 2006), 1–34; Henry Chesbrough, *Open Services Innovation: Rethinking Your Business to Grow and Compete in a New Era* (San Francisco: Jossey-Bass, 2011, Kindle edition); Eric von Hippel, *Democratizing Innovation* (Cambridge, MA: MIT Press, 2005); Yochai Benkler, "Coase's Penguin, or Linux and the Nature of the Firm," *Yale Law Journal* 112 (2002): 371–446.

2   Christina Raasch, Cornelius Herstatt, and Kerstin Balka, "On the Open Design of Tangible Goods," *R&D Management* 39, no. 4 (2009): 382–93.

3   Chris Anderson, *Makers: The New Industrial Revolution* (New York: Crown, 2012).

4   Hilde Bouchez, "Pimp Your Home: Or Why Design Cannot Remain Exclusive—From a Consumer Perspective," *The Design Journal* 15, no. 4 (2012): 461–78.

5   Lars Bo Jeppesen and Karim R. Lakhani, "Marginality and Problem-Solving Effectiveness in Broadcast Search," *Organization Science: Articles in Advance* 21, no. 5 (2010): 1016–33.

6   Fabrizio Salvador, Pablo Martin de Holan, and Frank Piller, "Cracking the Code for Mass-Customization," Sloan Management Review 50, no. 3 (2009): 71–78.

7   Eric von Hippel and Georg von Krogh, "Open Source Software and the 'Private-Collective' Innovation Model: Issues for Organization Science," *Organization Science* 14, no. 2 (2003): 209–23.

8   Sanne van der Beek, "From Representation to Rhizome: Open Design from a Relational Perspective," *The Design Journal* 15, no. 4 (2012): 423–42.

9   von Hippel, *Democratizing Innovation,* 17.

Introduction

The shift from closed to open paradigms in new product development is seen as an emergence of new forms of production, innovation, and design.[1] Innovation processes are shifting from open source software to open source hardware design. Emulating open source software, design information for open source hardware is shared publicly to enhance the development of physical products, machines, and systems.[2] Similarly, the rise of the "maker culture" enhances product tinkering,[3] while the do-it-yourself (DIY) movement embraces "the open" in design.[4] Users participate in design via crowdsourcing and co-creation on platforms such as OpenIdeo and Quirky and by joining proliferating open innovation challenges.[5] At the back end of the design process, customers are invited to participate in mass customization and personalization to personalize products.[6]

The open paradigm has received scholarly attention through studies of open source software[7] and open source hardware.[8] Moreover, user engagement in the design process has been studied as user-centric innovation,[9] participatory design,[10] and co-design,[11] as well as customer co-creation and crowdsourcing.[12] However, the "open" landscape in design lacks consensus regarding a unified definition for open design practices. This lack of agreement partially results from the gap in approaches to design. Studies of innovation and new product development are focused on user-centric approaches and customer engagement in several stages of the design process, whereas current definitions of open design are focused on openness of technical design information and largely exclude, in particular, the early stages of the design process. The open design definitions also lack the commercial aspects of openness. Thus, the existing definitions are too narrow to holistically represent the shift from a closed paradigm to an open paradigm in design. Moreover, the lack of clarity and consistency in definitions is hindering the development of open design as a design approach. To fully advance the research on methods and practices, a more comprehensive perception of openness in the design process is needed.

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10 Douglas Schuler and Aki Namioka, *Participatory Design, Principles and Practices* (Hillsdale, NJ: Erlbaum, 1993).

11 Elizabeth B.-N. Sanders and Pieter Jan Stappers, "Co-Creation and the New Landscapes of Design," *CoDesign* 4, no. 1 (2008): 5–18.

12 Tanja Aitamurto, Aija Leiponen, and Richard Tee, *The Promise of Idea Crowdsourcing—Benefits, Contexts, Limitations,* Whitepaper for Nokia Ideas Project, 2011, http://www.crowdsourcing.org/document/the-promise-of-idea-crowdsourcing--benefits-contexts-limitations/5218 (accessed July 7, 2014); Frank T. Piller, Christoph Ihl, and Alexander Vossen, "Customer Co-Creation: Open Innovation With Customers. A Typology of Customer Co-Creation in the Innovation Process," in *New Forms of Collaborative Innovation and Production on the Internet* (Göttingen, Germany: Universitätsverlag Göttingen, 2011), 31–61.

13 Tom Caswell et al., "Open Content and Open Educational Resources: Enabling Universal Education," *The International Review of Research in Open and Distance Learning* 9, no. 1 (2008): 1–11; Oved Nov and George Kuk, "Open Source Content Contributors' Response to Free-Riding: The Effect of Personality and Context," *Computers in Human Behavior* 24, no. 6 (2008): 2848–61; Yukika Awazu and Kevin C. Desouza, "Open Knowledge Management: Lessons from the Open Source Revolution," *Journal of the American Society for Information Science and Technology* 55, no. 11 (2004): 1016–19.

14 Brian Giza, "The Use of Free, Open-Source, and Web-Based Tools in Education," in *Proceedings of Society for Information Technology and Teacher Education International Conference 2009* (Chesapeake, VA: AACE, 2009), 1838–42; Karim R. Lakhani and Robert G. Wolf, "Why Hackers Do What They Do: Understanding Motivation and Effort in Free/Open Source Software Projects," in *Perspectives on Free and Open Source Software,* ed. J. Feller et al., (Cambridge: MIT Press, 2005), 3–22.

15 Janet Hope, "Open-Source Biotechnology" (PhD diss., The Australian National University, 2004).

This paper develops an overarching definition for open design and a three-layered framework for design practices. The definition covers the design process from initial problem definition in the beginning through to commercialization and licensing of the final design. Thus, the definition takes into account not just the openness of products, but even more so, the *openness of processes*. The conceptualization of open design enhances understanding of the design ecosystem, which is rapidly changing because of the digitalization of design tools and practices and the permeation of participatory culture. This culture alters design practices by raising funding as crowdfunding and the development of concepts in open design projects.

The paper is structured as follows: First we give an overview of the existing literature and definitions of open design practices and related work in co-creation, participatory design, crowdsourcing, and open innovation. Then we introduce the new definition for open design. The paper concludes with a research agenda for open design.

Background: Open Products and Open Processes
In the following we will review two aspects of openness, those of open products and open processes.

Open Products
Several terms, including open content, open source content, and open knowledge, are used to refer to content (e.g., images or text files) shared under a license that grants users the right to modify and re-use that content.[13] Well-known examples include Wikipedia and the Creative Commons licensing project. In this paper, open content refers to any text or media files that are shared under an open license.

Free and open source software (FOSS) is software distributed under either a "free software" or "open source" license. It gives users the right to run, study, modify, and redistribute the software source code as they wish. FOSS can therefore be considered a specific type of open content. Although some philosophical differences exist between the "free" and "open source" movements, three terms (i.e., open source software, free/libre and open source software, and FOSS) are often used interchangeably in the literature.[14] In this paper, we use FOSS as an inclusive description.

FOSS has been successful in the software industry. An increasing number of researchers and practitioners have suggested that the success of FOSS could be replicated in other industries.[15] Vallance et al. suggested "open design" as the term for describing the sharing of design information, such as schematics, computer numerical control (CNC) files, and documentation.[16] This terminology has been used by others,[17] while in the technical literature, open hardware and open source hardware are often the terms

16 Ryan Vallance, Sepehr Kiani, and Samir Nayfeh, "Open Design of Manufacturing Equipment," in *CHIRP 1st International Conference on Agile, Reconfigurable Manufacturing* (Ann Arbor: University of Michigan, 2001), www.opendesign.org/CHIRP_Open_Design_Mfg_Equipment.pdf (accessed September 12, 2014).

17 Raasch, Herstatt, and Balka, "On the Open Design of Tangible Goods," 84.

18 Giorgio Metta et al., "The iCub Humanoid Robot: An Open Platform for Research in Embodied Cognition," in *Proceedings of the 8th Workshop on Performance Metrics for Intelligent Systems* (Gaithersburg, MD: Association for Computing Machinery, 2008), 50–56.

19 Open Source Hardware Association, "Open Source Hardware Definition," http://www.oshwa.org/definition (accessed March 1, 2013).

20 Raasch, Herstatt, and Balka, "On the Open Design of Tangible Goods," 383–84.

21 Vallance, Kiani, and Nayfeh, "Open Design," 3–5.

22 von Hippel, *Democratizing Innovation,* 93–106.

23 Margit Osterloh and Sandra Rota, "Open Source Software Development—Just Another Case of Collective Invention?" *Research Policy* 36, no. 2 (2007): 157–71.

24 David P. Myatt and Chris Wallace, "Equilibrium Selection and Public Good Provision: The Development of Open-Source Software," *Oxford Review of Economic Policy* 18, no. 4 (2002): 446–61; Jürgen Bitzer, Wolfram Schrettl, and Philipp J. H. Schröder, "Intrinsic Motivation in Open Source Software Development," *Journal of Comparative Economics* 35, no. 1 (2007): 160–69.

25 Coimbatore K. Prahalad and Venkatram Ramaswamy, "Co-Opting Customer Competence," *Harvard Business Review* 78, no. 1 (2000): 79–90.

26 Bernard Cova and Stefano Pace, "Brand Community of Convenience Products: New Forms of Customer Empowerment– The Case of 'My Nutella the Community,'" *European Journal of Marketing* 40, no. 9/10 (2006): 1087–105.

27 Allan Afuah and Christopher L. Tucci, "Crowdsourcing as a Solution to Distant Search," *Academy of Management*

used to describe this sharing of design information. For example, Metta et al. use both terms while describing the development of an "open" robotics platform.[18] Although hardware is sometimes understood to refer specifically to electronic components, the open source hardware definition is intended to cover all "tangible artifacts—machines, devices, or other physical things."[19] Meanwhile, design can mean a process, the documentation of that process, or its end product. Furthermore, clear differences exist in the nature of open source software development and open source hardware design.[20] In open source software, the collaborative action leads to a unified software artifact. In open source hardware design, the outputs are a collection of several different physical artifacts. Therefore, we propose that the definition of open design used by Vallance et al.[21] is too restrictive to describe the full design process and instead use "open source hardware" (OSH) to refer to shared information related to physical artifacts.

The majority of the literature on open products tries to explain the processes associated with the products' creation. For example, FOSS production has been treated as an example of user-centered or user-driven innovation,[22] compared to "collective invention" processes,[23] and has been modeled from the perspectives of a range of economic theories.[24] However, the current conceptualization of openness as used in FOSS, OSH, and open content definitions refers only to the license under which the end product is distributed. Although these licenses do often facilitate an "open" process of voluntary, distributed collaboration, such a process is neither necessary nor sufficient to qualify a project as open under the current definition. Although this process is discussed in the literature, it is not clearly defined. The aim of this article is therefore to develop a definition for open design that takes into account the entire design process, rather than just the means of distributing the final product. The following section describes theories and definitions related to open processes that can provide guidance in developing a new, comprehensive definition of open design.

Open Processes
"Co-creation" refers to a collaborative action between employees and the external participants (the "crowd"). In co-created processes, the experts and amateurs—the company and the customers—work together, with two-way interactions between both groups and peer-to-peer communication among customers.[25] This approach results in a co-created experience, as noted in studies of online customer and brand communities.[26] These participatory mechanisms address consumers' growing demand for personalized experiences. Such collaborative modes of design can be autonomous and can be started by individuals that are not part of a coordinated organization. Loose groups can then form.

Review 37, no. 3 (2012): 355–75; D. C. Brabham, *Crowdsourcing* (Cambridge, MA: MIT, 2013).

28 Benkler, "Coase's Penguin," 21.

29 Brabham, *Crowdsourcing*, xxi.

30 Daren C. Brabham, "Moving the Crowd at Threadless: Motivations for Participation in a Crowdsourcing Application," *Information, Communication & Society* 13, no. 8 (2010): 1122–45.

31 Tanja Aitamurto, *Crowdsourcing for Democracy: New Era in Policy Making* (Committee for the Future, Parliament of Finland, 2012), http://www.scribd.com/doc/118136573/Crowdsourcing-for-Democracy-New-Era-in-Policy-Making (accessed July 7, 2014); Tanja Aitamurto and Hélène Landemore, "Democratic Participation and Deliberation in Crowd-sourced Legislative Processes: The Case of the Law on Off-Road Traffic in Finland," 6th Conference on Communities and Technologies (Munich: Technische Universtität Munich, 2013.), http://cochette.xrce.xerox.com/comtech13/papers/paper1_aitamurto_landemore.pdf (accessed July 7, 2014).

32 Thomas J. Howard et al., "Open Design and Crowdsourcing: Maturity, Methodology and Business Models," in *Conference Proceedings–International Design Conference* (Zagreb: Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia, 2012); Marion K. Poetz and Martin Schreier, "The Value of Crowdsourcing: Can Users Really Compete with Professionals in Generating New Product Ideas?" *Journal of Product Innovation Management* 29, no. 2 (2011): 245–56.

33 Tim Kappel, "Ex Ante Crowdfunding and the Recording Industry: A Model for the U.S.," *Loyola of Los Angeles Entertainment Law Review* 29 (2009): 375–85.

34 Jeppesen and Lakhani, "Marginality," 1020.

35 Larry, Huston and Nabil Sakkab, "Connect and Develop," *Harvard Business Review* 84, no. 3 (2006): 58–66.

36 Karim R. Lakhani et al., "OpenIDEO," Technology & Operations Mgt. Unit Case No. 612-066 (Cambridge, MA: Harvard Business School, 2012).

Crowdsourcing can be defined as a problem solving and production system in which a crowd is enlisted to help solve a problem defined by a system owner.[27] The difference between crowdsourcing and commons-based peer production[28] (e.g., contributing to Wikipedia or to open source software projects) is that in crowdsourcing the locus of power in managing and coordinating the process is in the crowdsourcer.[29] The crowdsourcer—which decides the focus of crowdsourcing, what to do with the output, and so on—can be a company, an organization, or an informal group of people, for example. Meanwhile, in commons-based peer production, top-down management in the intended design is either minimal or nonexistent. The collective of contributors have the power.

Crowdsourcing is increasingly used in a variety of capacities. For instance, it is used in creative work, such as T-shirt design;[30] in policy-making;[31] and in distributed human intelligence micro-tasking, such as Amazon's Mechanical Turk. It is also used for developing companies' new product ideas.[32] Finally, it is used for crowdfunding projects and new products on platforms such as KickStarter.[33] The problem is typically clearly defined, and it can range from a small fraction of a larger problem (typically called a "micro-task") to the full design of a product. Online innovation challenges are used by organizations as a crowdsourcing technique to gather ideas and solutions from "the crowd." Companies use innovation intermediaries, such as InnoCentive,[34] NineSigma,[35] or OpenIdeo,[36] to discover solutions via innovation challenges, or they use their own platforms to harvest ideas from crowds.[37] These innovation challenges function not only as a source of new products or improvements for existing products but also as need-finding tools to identify users' needs in diverse cultural, geographical, and socio-economic contexts.

Participatory design (PD) is an approach where non-designers are included in the design process. The rationale behind this approach is to better meet people's actual needs by allowing end-users and other stakeholders to take part in the design work itself.[38] The active participation of people who understand the context in which new products and new services will be used, increases the likelihood that new solutions will be accepted and sustained by the intended users.[39] Ideally, participants should therefore take part in the entire process, including need finding, idea generation, prototyping, and testing. The designer should facilitate the process, rather than dictate the product or service development.[40]

PD has evolved from being focused mainly on the development of information and communications technology to comprising a wide array of fields, such as space design, product development, industrial design, architecture, and service design.[41] Although PD practitioners belong to various academic disciplines, they share certain views: (1) design ideas arise in collaboration with

37 Paul M. Di Gangi and Molly Wasko,
    "Steal My Idea! Organizational Adoption
    of User Innovations from a User Innova-
    tion Community: A Case Study of Dell
    IdeaStorm," *Decision Support Systems*
    48, no. 1 (2009): 303–12.

38 D. Schuler & A. Namioka, *Participatory
    Design: Principles and Practices*
    (L. Erlbaum Associates Inc, 1993), xi.

39 Toni Robertson and Jesper Simonsen,
    "Challenges and Opportunities in Con-
    temporary Participatory Design," *Design
    Issues* 28, no. 3 (Summer 2012): 3–9.

40 Oscar Arce, "Participatory Design, Chal-
    lenges and Experiences Using Design in
    Development," in *Design without Bor-
    ders: Experiences from Incorporating
    Industrial Design into Projects for Devel-
    opment and Humanitarian Aid,* edited by
    Åse Kari Haugeto and Sarah Alice Knut-
    slien (Oslo: Norsk Form, 2004), 45–50.

41 Elizabeth B.-N. Sanders, Eva Brandt, and
    Thomas Binder, "A Framework for Orga-
    nizing the Tools and Techniques of Partic-
    ipatory Design," in *Proceedings of the
    11th Biennial Participatory Design Con-
    ference* (New York: ACM Press, 2010),
    195–98.

42 Henry Sanoff, "Editorial: Special Issue on
    Participatory Design," *Design Studies* 28,
    no. 3 (2007): 213–15.

43 Sanders and Stappers, "Co-Creation and
    the New Landscape," 7.

44 See, e.g., the special issue of *Design
    Issues* 28, no. 1 (Winter 2012).

45 Robertson and Simonsen, "Challenges
    and Opportunities," 4.

46 von Hippel, *Democratizing Innovation,* 19.

47 Ibid., 23–25

48 Elizabeth B.-N. Sanders, "Design
    Research in 2006," *Design Research
    Quarterly* 1, no. 1 (2006): 1–8.

49 Henry Chesbrough, *Open Business Mod-
    els: How to Thrive in the New Innovation
    Landscape* (Cambridge, MA: Harvard
    Business School, 2006, Kindle edition), 2.

50 Chesbrough, *Open Services Innovation,*
    777.

51 Chesbrough, *Open Innovation*, 2.

52 Chesbrough, *Open Business Models,*
    2181.

53 Ulrich Lichtenthaler, "Open Innovation in
    Practice: An Analysis of Strategic
    Approaches to Technology Transactions,"
    *IEEE Transactions on Engineering Man-
    agement* 55, no. 1 (2008): 148–57.

participants from various backgrounds; (2) designers should spend time with users in their own environments, rather than focusing on tests in laboratories; and (3) decisions should be made democrati- cally with the participants rather than by the designers alone.[42] According to Sanders and Stappers, *co-design* is an updated term for PD.[43] However, PD is also still frequently used in current literature.[44] In this paper, we therefore use the two terms synonymously.

User participation is central to the development of current trends in user-centered design and user-driven innovation.[45] At the core of user-driven innovation are "lead-users"—organizations or individuals who already face the needs that will dominate the market in the future.[46] They benefit from finding a solution to these needs and can thus serve as need-forecasting groups. Because lead-users often try to meet their own needs, they can also provide valuable design ideas and concepts.[47] Lead-user innovation has common elements with co-design because the recipients of design are included in the design process. However, as noted by Sanders, the lead-user approach is fundamentally different from PD because it assumes that only specific types of users can add value to the development process through their participation.[48] Lead-users rep- resent elite experts; thus, lead-user innovation does not necessarily address the needs and dreams of the majority of people.

Open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively."[49] Organizations increasingly use open innovation as a strategic tool to increase the flow of knowledge to and from the organization and to increase R&D productivity. Simultaneously, organizations seek to discover new ways to commercialize innovations within and beyond their own boundaries. By applying the open innova- tion strategy, the company can move toward an open business model (also called a platform business model), in which the value and revenue are co-created with collaborators.[50] An open innova- tion process includes three core processes: an outside-in process, an inside-out process, and a coupled process. In the outside-in process, firms enhance their knowledge base by tapping the wis- dom of their suppliers, customers, and other related actors. This inbound open innovation leverages the discoveries of others, and organizations become less dependent on their internal R&D.[51] Open innovation also engages an inside-out process, which exter- nalizes innovation processes to bring ideas to market faster. A company can do so by licensing its own intellectual property, as well as by reaching new markets through spin-offs and part- nerships, thus increasing overall revenue while saving R&D resources.[52] In these cases, companies use partners to find new markets and business models for their technologies.[53] The third ideal type in the open innovation process is a coupled process, in which companies create alliances, partnerships, and joint ventures,

Figure 1
Open design practices and design process.

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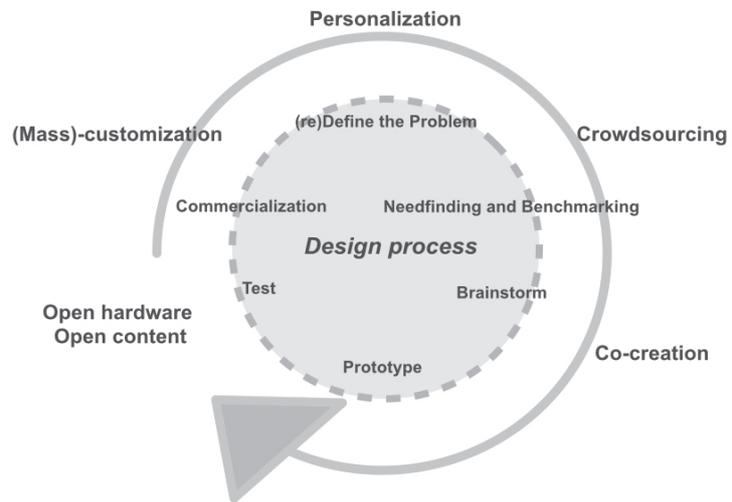
thus co-creating value for both parties. In these instances, companies combine the outside-in and inside-out processes, commercializing innovations with partners and sharing complementary resources—for instance, by deploying open application programming interfaces (APIs).[54] Co-creation and crowdsourcing can be used as tools in deploying open innovation strategies, as is done with open innovation challenges. Organizations can also apply PD and co-design approaches to deploy the open innovation principles in practice.

Introducing Three Layers of Open Design
In this section, the definition of open design is rearticulated to better address developments in the open paradigm and to update the design research paradigm accordingly. The new definition is crafted as follows:

> The open design process provides public access to participation in the design process and to the product resulting from that process, as well as the data created in the design process, including technical details and other data and content gathered or generated during the process.

The redefined concept of open design includes all the stages in the design process, from need-finding to ideation, and in the production process, intertwining the aspects of technical, legal, and commercial openness, as illustrated in Figure 1. Openness refers to a publicly accessible possibility to participate in the design process, so that both non-designers and designers participate. As a result, the boundaries between experts and non-experts become porous. Instead of inviting only the lead-users to participate in the design process, open design practices invite everyone to participate, regardless of their qualifications, skills, or professional

54   Tanja Aitamurto and Seth C. Lewis, "Open Innovation in Digital Journalism: Examining the Impact of Open APIs at Four News Organizations," *New Media and Society* 15, no. 2 (2013): 314–31.

position. Open design is also differentiated from traditional PD practices in that the process is inherently open to the public and is not only for invited participants.

Moreover, open design also includes later stages in design, such as the commercialization of the product and the publishing of content produced during the design process, such as blueprints and other technical details. Thus, the new definition of open design comprises open source hardware, open source software, open design processes, open commercialization, and open content. It expands on the definitions introduced previously in the literature to incorporate and address openness not just in the product, but in both the process and the product, as illustrated.

Open design principles are applied by using open design practices, as illustrated in Figure 1, and openness can manifest in several stages of the design process. For instance, only the need-finding process might be open, or only the source-code might be publicly available. The design process is illustrated as a cycle to emphasize the recurring stages (e.g., testing) in the process. Moreover, the degree of openness can also vary in the design process. Openness is operationalized by deploying participatory methods, such as crowdsourcing and co-creation. For instance, to design a more functional refrigerator, the tasks could include videos of people loading and unloading a refrigerator, or pointing out the problems and advantages of current refrigerators in pictures. Alternatively, designers might post their initial concepts on online platforms for comments (e.g., on Quirky) and thus co-create their designs with users. See Table 1 for descriptions of other possible open design practices.

To further demonstrate the practices of open design, we expand the typology of Piller et al., which in its original form describes collaboration between a company and a customer.[55] In the framework developed here, open design practices are deployed in the following stages: 1) listening in, 2) interacting and creating with co-designers and the crowd, and 3) sharing with other co-designers and the crowd. These three layers describe both autonomous design processes and customer–company collaboration. At least one of these three layers of open design practices can occur in an open design process.

Layer 1: Listening In
In the first layer, a designer gathers information about the design task by observing behavior in offline and online communities. For example, customer needs can be observed in online design communities (e.g., 99Design and Jovoto) and customer co-creation communities (e.g., OpenIdeo and Lugnet). The methodology can include netnography[56] or empathic design.[57] This mode differs from traditional customer surveys and research reports in that the designer senses the customers' needs by using information

55 Piller, Ihl, and Vossen, "A Typography of Customer," 37.

56 Robert V. Kozinets, "On Netnography: Initial Reflections on Consumer Research Investigations of Cyberculture," in *Advances in Consumer Research,* edited by Joseph W. Alba and Wesley Hutchinson Vol. 25 (Provo, UT: Association for Consumer Research, 1998), 366–71.

57 Dorothy Leonard-Barton and Jeffrey F. Rayport, "Spark Innovation through Empathic Design," *Harvard Business Review* 75, no. 6 (1997): 102–13.

gathered from open online communities rather than by using more traditional, closed methods. The designer can also explore the users' needs through sites where ideas for new solutions are shared and discussed, and thus have access to information, which would be otherwise beyond her or his reach. Several online platforms allow people to share ideas for products (and thus indirectly express needs experienced by themselves or others). For example, Quirky.com allows anyone to submit design ideas via the website and iPhone app. The ideas are then vetted, voted on, and developed further by the Quirky community. The most successful ideas are developed into products by the Quirky design team and sold at the Quirky store. The crowd can contribute in multiple ways in the design process, including defining the product requirements and providing input on product appearance, name, and price. The inventors are rewarded, and the contributors get a share of the royalties based on product sales. Other companies can follow such sites strategically to monitor reoccurring themes, needs, and gaps in the solutions offered on the market today, thus sensing the markets.

Layer 2: Interacting and Creating With
In the second mode, the designers cease to be observers and become participant–observers, a role that includes interaction and co-creation with the users and co-designers. Participants take an active role as co-creators; and designers interact with the crowd to gain feedback. This feedback can include payment when participants express needs and interest through crowdfunding. Crowdfunding functions as a means of identifying needs, probing interest, and testing ideas: If the crowd funds the design, the funders likely desire the design.[58] Crowdfunding happens on crowdfunding plaforms like Kickstarter and IndieGoGo. Co-designers publish early concepts and develop ideas on sites such as OpenIDEO. The second mode is also expressed in design challenges, in which co-designers share ideas in public and invite feedback. The stage of these designs varies from early ideas to highly developed prototypes. For instance, Wells Fargo asks for customer feedback on prototypes through its Wells Fargo Labs. These designs might be early prototypes or newly launched services. Such online platforms function as live focus groups for designers to observe and interact with users.[59] In this mode, the users also can tinker with the products by personalizing them and mass-customizing them. When interacting with the users and other co-designers, designers are applying PD practices while including as many stakeholders as possible in the design process.

Run by the design firm IDEO, OpenIDEO is an initiative that seeks the benefits of interacting and creating with the general public in designing for social innovation. Design challenges are posted on the site, openideo.org, by "challenge sponsors." The

58 Tanja Aitamurto, "The Role of Crowdfunding as a Business Model in Journalism: A Five-layered Model of Value Creation," in *Crowdfunding the Future: Media Industries, Ethics and Digital Society,* eds. Bertha Chin, Lucy Bennett, and Bethan Jones. Peter Lange (2015).

59 Georg von Krogh, Kazuo Ichijo, and Ikujiro Nonaka, *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation* (Oxford: Oxford University Press, 2000).

crowd is invited to share stories, inspirations, and need-finding insights. Then, in the next phase, employees at IDEO generate concept ideas together with the crowd, thus building on each other's ideas. Based on the crowd's feedback, IDEO selects the best ideas, together with the challenge sponsor. The short-listed ideas are then further refined, iterated, and prototyped with the crowd's input. The crowd rates the concepts based on some key criteria before IDEO and the challenge sponsor select the winning concept. The product realization might be done by IDEO or the challenge sponsor alone, or together with selected community members.

Layer 3: Share With
In this layer, the technical details about the design are shared in public, whether they are source code or hardware details. Openness is achieved by publishing, for example, the open source code and/or hardware information. The data gathered during the design process can also be published and made publicly available.[60] The open content can also include such data as supply chain information and environmental impact assessments (e.g., the carbon footprint). The principles of open innovation can be used in the commercialization of the design by enhancing the flows of innovation to the company and from the company.[61] Openness can be also deployed via open APIs, which enable the use of content on another website or service through smooth technological integration. Thus the API serves the designer's end-product. Openness can also be used in the early stages of design by applying crowdsourcing and co-creation in problem-definition, need-finding, and detailed design. However, in the second mode, the focus is on active co-building and interacting, whereas in the third layer the focus is on publishing the data on the process and the product.

New technologies like 3D printers and accessible software are transforming how design is being done. In January 2013, Nokia became the first major manufacturer to give consumers access to its 3D design files so that they could create their own versions of products. The company released digital files allowing users to alter and 3D-print their own shells for the Lumia 820 smartphone. Consumers are thus enabled not only to contribute with ideas and input but also to access blueprints and technology to personalize and further develop products on their own. This capability requires access to a 3D printer, which may provide a barrier to entry for consumers. However, open source 3D printers such as the RepRap (short for "replicating rapid prototyper") have made this technology affordable and accessible in recent years. The RepRap prints objects in plastic. It can also print its own components and function as a self-replicating manufacturing machine[62] —although electronic components must be purchased separately.

60 On open data, see George Kuk and Tim Davies, "The Roles of Agency and Artifacts in Assembling Open Data Complementarities," in *Proceedings of the International Conference on Information Systems ICIS 2011* (Shanghai: ICIS, 2011).

61 Chesbrough, *Open Business Models,* 45.

62 Rhys Jones, Patrick Haufe, Edward Sells, Pejman Iravani, Vik Olliver, Chris Palmer, and Adrian Bowyer, "RepRap – The Replicating Rapid Prototyper," *Robotica* 29 (2011): 117–91.

The printer is controlled by an open source desktop software. All of the 3D designs produced by the project are released under a free software license, the GNU General Public License.

The Benefits of Applying Open Design Practices

Open design practices hold the potential to contribute to the design process in several ways. When solutions are crowdsourced and co-created, more solutions for the design challenge can be presented than in a closed process. This variety of options can help a designer find the optimum solution, saving time and money, and the input of users and co-designers can improve the end result. Some research indicates that problem-solvers outside the specific knowledge area of the problem (e.g., physics, chemistry, mechanical engineering) can, through crowdsourcing, help devise novel solutions.[63] For example, in a study of crowdsourcing in new product development, the non-expert users created solutions that had greater novelty and customer benefit than those solutions created by experts, according to the evaluation panel (professional engineers and designers). However, the solutions were, admittedly, somewhat lower in terms of feasibility.[64] In this study, the evaluation panel was blind to the source of the ideas (professionals vs. users). These findings support the notion of collective intelligence, which suggests that a distributed and diverse population can prove to be more capable for certain tasks than a couple of experts (see Table 1).[65]

63 Jeppesen and Lakhani, "Marginality," 1028.
64 Poetz and Schreier, "The Value of Crowdsourcing," 251.
65 Pierre Lévy and Robert Bonomo, *Collective Intelligence: Mankind's Emerging World in Cyberspace* (Cambridge, MA: Perseus, 1997).

Table 1 │ Openness in the Design Process

Design Phase	Methods
Need-finding	· Crowdsourcing needs (e.g., in online communities through interactions with end-users) · Ethnographic methods
Ideation and concept generation	· Publicly open brainstorming · Crowdsourcing and co-creation of concepts · Crowdsourcing evaluations and discussions of ideas · Co-creation of concepts by users and with users · Testing problem-definition with users
Detailed design	· Crowdsourcing designs · Co-creating prototypes with customers, users, and online participants and testing prototypes with them
Manufacturing	· Mass-customization and personalization of designs
Distribution	· Open licensing of content, code, and design specifications (e.g., by using Creative Commons licenses, FOSS licenses, and OSH licenses)
Testing	· Crowdsourcing feedback from users · Opening prototypes for testing · Co-creating redesigns/improvements of prototypes
Commercialization	· Applying the principles of open innovation (e.g., in licensing, open APIs, marketing)

Furthermore, participation in the design process can result in an effect known as the "pride of authorship," which has been noted in studies of user participation in new product development.[66] This sense of pride can, in turn, lead to a greater willingness to pay for the end-product and a stronger feeling of ownership, as noted in co-creation studies.[67]

A commonly claimed advantage of the open approach in FOSS is "Linus's Law," which states that "given enough eyeballs, all bugs are shallow."[68] In other words, with a large enough community of users and developers, any software problems can be identified and resolved quickly. This perspective goes against common wisdom in software development and other fields, which states that larger groups are less likely to achieve their goals.[69] An empirical study conducted by Schweik et al.[70] investigated more than 100,000 FOSS projects and found a correlation between the number of developers involved in a project and the likelihood of a project's success. This result strengthens the argument for Linus's Law.

The more open the design process is, the more it fits with the notion of belonging to a public domain. It is accessible to the crowd in the sense that the crowd can participate in it, use it, tinker with it, and build on the outcomes it produces. Thus, open design can be seen as a democratizing force in society. However, openness raises important concerns about divisions of labor and the abuse of amateurs to save the cost of hiring expert designers.[71] These concerns follow larger societal developments appearing in several fields, including journalism[72] and the music industry.[73] Openness is a double-edged sword that can advance society while simultaneously tearing existing structures apart.

The rearticulated definition of open design allows design researchers and co-designers to perceive the design process in a holistic manner, and to include participants outside an organization. Open design has unrestricted participation as its ultimate goal; however, technology access and a lack of programming skills, for example, can limit people's opportunities for participating in and influencing the design process. PD does not necessarily have to be fully "open," in that only invited/included participants might be given the opportunity to participate. Open design, meanwhile, inherently requires participatory approaches. Even when the design process is partially or fully open, not everybody wants to participate or has the skills to do so. Thus, systems for unhampered, open participation have to be designed with usability and ease of access in mind to encourage users to contribute.

66 Jenny Preece, Yvonne Rogers, and Helen Sharp, *Interaction Design: Beyond Human-Computer Interaction* (New York: Wiley, 2002).

67 Tanja Aitamurto, "Balancing Between Open and Closed: Co-Creation in Magazine Journalism," *Digital Journalism* 1, no. 2 (2013): 229–51.

68 Eric Raymond, "The Cathedral and the Bazaar," *Knowledge, Technology and Policy* 12, no. 3 (1999): 23–49.

69 Frederick P. Brooks, *The Mythical Man-Month* (Reading, MA: Addison-Wesley, 1975).

70 Charles M. Schweik et al., "Brooks' versus Linus' Law: An Empirical Test of Open Source Projects," in *Proceedings of the 2008 International Conference on Digital Government Research* (Montreal: Digital Government Society of North America, 2008), 423–24.

71 Andrew Keen, *The Cult of the Amateur: How Today's Internet is Killing Our Culture* (New York: Doubleday, 2007); Tiziana Terranova, *Network Culture: Politics for the Information Age* (London: Pluto Press, 2004).

72 See Daniel Kreiss, Megan Finn, and Fred Turner, "The Limits of Peer Production: Some Reminders from Max Weber for the Network Society," *New Media & Society* 13, no. 2 (2011): 243–59.

73 N. K. Baym and R. Burnett, "Amateur Experts: International Fan Labour in Swedish Independent Music," *International Journal of Cultural Studies* 12, no. 5 (2009): 433–49.

Research Agenda for Open Design

The framework for open design developed in this paper examines a variety of methods for using open practices in the design process. The goal of this framework is to create a systematic and holistic approach to open design practices and to intertwine the aspects of co-design. To examine the implications of open design practices, further research is needed. This paper concludes by suggesting research questions that examine further the phenomenon of "open" in design research.

First, the effect of openness—both in product and in process—on quality of design has to be studied further. Experiments need to be conducted in which the effect of openness on design features (e.g., novelty, desirability, and feasibility) can be measured. In addition, the relationship between openness in process and in product has to be further studied. Empirical research can identify the best practices for intertwining the openness in process with the openness of product, and the optimal balance in openness.

Second, as the previous research indicates, participation in the design process can affect the participants' ownership of the end-product and their willingness to pay for the design. This relationship needs to be studied further by measuring the effect of participation on users' desire for the product, controlling for the degree of participation. Moreover, the strength of participation likely varies based on the initiator of the design process (e.g., company, group, individual). These differences need to be examined in future research.

Third, expanding access to knowledge (in an open data manner) that is created during the open design process is becoming more common. Research has yet to address how the data commons produced in the design process can be useful, for whom it can be useful, and in which formats it should be published.

Fourth, the aspects of openness need to be examined in PD practices. The question of how to apply online practices and wider openness to PD remains largely unstudied. Posing these questions in the context of developing countries is particularly crucial. For example, the inclusion of stakeholders in the design process with low-end technologies, such as mobile phones, can lead to wider empowerment of end-users in suppressed and unprivileged societies. Acknowledging both the cultural and political dimensions of design holds the potential to increase transparency in design and manufacturing processes, and thus to democratize innovation and mitigate the power asymmetries in innovation.

Finally, the open paradigm is celebrated as a democratizing force in design, following the discourse in other realms of society. However, the research has yet to address questions concerning the effect of open practices on the division of labor. A critical approach to the implications of the concept of "open" is needed to address the following research questions: How will the expansion of "the designer crowd" effect the craftsmanship of professional designers and their job prospects? Is "open" equivalent to "free"; and what does "free" mean here? For whom is the object in question "free"; and might "free"—or open—mean exploitation of people willing or having to work for free? Promoting free labor and reducing the need to hire paid staff could be an unintended side effect of open design. For instance, if a design company successfully uses practices of open design to distribute work for the crowd beyond the company's borders, the need to reduce design staff can rise. However, it is yet to be examined to what type of tasks and processes open design practices fit so that the work can be done as efficiently as with professional, hired design staff. That might not be possible at all, and therefore, the scenario about drastic changes in labor distribution amond designers might not come to reality.