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A taxonomy of users' active design engagement in the 21st century

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People not only purchase and use products and services, but creatively appropriate, hack, redesign and even innovate in them. Typologies of active use have emerged in various disciplines, remaining piecemeal even if complementary. Together they produce a blurry depiction of active design engagement, despite active use being pivotal to many emerging design approaches. To remedy this, we synthesize a taxonomy of different aspects of active use and design engagement. Use as-is, active use, locally new designs and globally new innovations mark different intensities of engagement. These can concern the material form of design, new uses, new meanings, adjustment to local settings, or the collective endeavours to shape communities and organizations, ideologies and imaginaries, and global platforms that facilitate active use.

Keywords: user participation, innovation, collaborative design, human factors, active use

People traditionally thought of as 'consumers' or 'users' of designed products and services engage in many design-related activities beyond routine purchasing and using of artefacts. The dichotomies between 'designers' and 'users' or 'designers' and 'non-designers' (Buchanan, 2001; Manzini, 2015; Woodhouse & Patton, 2004) no longer hold in the face of hacking, appropriating and making, (re)designing and even innovating done by those who adopt and use goods. There is simultaneously widespread recognition that makers, prosumers and user innovators are taking more roles in design and innovation, both as individuals and as part of broader design networks and communities (e.g. Margolin, 1997; von Hippel, 2005; 2016; Oudshoorn and Pinch, 2003; Rohracher, 2005; Sanders & Stappers, 2008; Hyysalo, Jensen, & Oudshoorn, 2016). Not only is today's range of actively design-engaged use practices diverse, it is also significant economically, societally and environmentally, as well as significant for the design profession (Bødker, Kensing, & Simonsen, 2004; Campbell, 2005; Redström, 2006, 2008; van Abel, Evers, Klaassen, & Troxler, 2011). The last three decades have witnessed whole suites of design approaches, both in research and practice, that are premised on further design being taken by people using the products and services. In participatory design, Henderson and Kyng (1992)

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elaborated the advantages of continuing collaborative design after implementation based on design adjustments made by users and not only in the envisioning stage (Ehn & Kyng, 1992). This has subsequently developed into design-in-use approaches including co-realization (Büscher, Christiansen, Hansen, Mogensen, & Shapiro, 2009; Hartswood et al., 2002), meta-design (Giaccardi & Fischer, 2008) and aging together (Botero & Hyysalo, 2013). The rise of hacking and making has, in turn, led to open design initiatives (Aitamurto, Holland, & Hussain, 2015; Bakırlıoğlu & Kohtala, 2019; Tooze et al., 2014; van Abel, Evers, Klaassen, & Troxler, 2011), designing with and for maker communities (Ratto & Boler, 2014; Özkil, 2017), and peer-content creation and crowdsourced design and innovation strategies (von Hippel, 2016). In all these research and practice approaches, the key underlying question is: what are people capable of and how are they engaging with designs-in-use, and thus, how can their engagement be supported and built upon?

It is central for design research and practice to understand that designers are not alone in seeking to understand and engage with active use, and in important respects have been followers rather than initiators in understanding the related phenomena. Many disciplines beyond design studies have made important contributions to the understanding of how people engage with design by observing and distinguishing what they do: what modes they adopt in engaging with products and technologies (e.g. Campbell, 2005; Eglash, 2004; Woodhouse & Patton, 2004); whether and how they innovate or not (e.g. von Hippel, 1976, 2005, 2016); and how they participate in design, production and consumption (e.g. Campbell, 2005; Shove, Watson, Hand, & Ingram, 2007; Simonsen & Robertson, 2012).

The plentiful empirical findings have gradually been worked into typologies and diagrams that clarify design–use relations in a particular context and from a particular research position. For much cited instances, Sanders (2006) demarcates between "customer, consumer, user, participant, adapter, maker, co-creator" (Figure 1); Eglash (2004) between "consumption, reinterpretation, adaptation, reinvention and production" (Figure 2); de Jong, von Hippel, Gault, Kuusisto, and Raasch (2015) between "routine use, user modifications and user innovations"; and Campbell (2005) between "cultural dupe, personalization, customization and craft consumption". Such demarcations typically serve well to classify design engagements in a manner relevant to a particular research domain such as user innovation (de Jong et al., 2015) or to advance an argument such as what demarcates craft consumption from mere personalization (Campbell, 2005). However, as these typologies have proliferated, subsequent authors have recognized both the complementarities and disparities between the proposed ways of classifying active use and engagement with design and began to cross-breed the simple typologies into

more comprehensive frameworks (e.g. Botero, 2013; Botero, Kommonen, & Marttila, 2010; Juntunen, 2014).

Examining these efforts reveals that, first, the simple typologies feature partially overlapping terminologies for users' design engagement and thus result in some redundancy of terms. Second, many typologies also partially diverge, covering different areas in users' active engagement. There are thus points of commonality and complementarity that have remained unacknowledged, particularly when typologies have been proposed in isolation in different fields of enquiry. This means important insights for one field that stem from, and are evident for, other bodies of literature have gone unrecognized, as do insights that elaborate upon the limitations and possibilities for active use and engagement with design. If taken together at face value, the varying existing typologies produce a conceptually blurry depiction of active design engagement with potentially over one hundred different types of active use. This conceptual blur hampers both researchers and practitioners in their engagements with active use, resulting in either keeping up with simplistic disciplinary typologies despite awareness of their limits, or attempts at fusing some, but not nearly all, relevant categories identified by previous research.

In the present article we analytically compare and synthesize into a taxonomy the most formidable typologies available. The resulting more encompassing taxonomy, on the one hand, condenses the wide array of partially overlapping terminologies and typologies developed to describe active use, and, on the other hand, it elaborates a broader range and intensity of activities than any one of the previously available typologies and taxonomies have suggested before.

As noted, added conceptual clarity is becoming needed not only research-wise but for empirical reasons as well: our post-industrial world is changing, and when one examines, for instance, peer-to-peer open design initiatives (Aitamurto et al., 2015; Halbinger, 2018; Kohtala, 2017; Özkil, 2017; Tooze et al., 2014), it is amply evident that formerly disparate frameworks are becoming relevant even within a single domain, pointing to the need for synthesis. Active user engagements in these open design settings surpass any one of the previously available frameworks, showing them to be far too restricted. We thus demonstrate a more nuanced taxonomy in sections 1.1 and 1.2, which is needed to understand the breadth and depth of user activities in the 21st century. We then proceed to give empirical examples of each of the 'cells' of the taxonomy to clarify what they mean, as well as to demonstrate that the considerably wider set of categories we identify in comparison to previous typologies is empirically relevant (section 2). Conclusions follow. We now move to examining the current literature, taxonomic categories and their distinctions in more detail and discuss the dimensions and distinctions they imply.

1 Typologies of active use and design engagement

1.1 Clarifying active use and engagement with design: contributions from different disciplines

Several disciplines have made important contributions to understanding active use and 'users'' active engagement with design and advanced, not only single contributions, but typologies of what it consists of and its variations. These typologies reflect differing intents and units of observation in these disciplines, as some aim to map existing user modes of engaging with products or services (e.g. Campbell, 2005; DeSanctis & Poole, 1994), others aim to further engage current or future users (e.g. Sanders & Stappers, 2008), and still others attempt to do both (e.g. von Hippel, 2005, 2016). Often the interest has been cast wider than active use, such as consumption studies' interest to study materiality in people's everyday life beyond just their active design engagements (Miller & Slater, 2007; Shove et al., 2007). The resulting diversity in the typologies provides a considerable source of complementary insights but equally a source of potential confusion. To avoid obfuscating the issue from the outset, we limit our focus to what people do with products and services when they engage 'first-hand' with their material qualities by themselves or with their peers as non-professional designers or producers. This means we exclude how people affect designs as informants or aides to professional designers or through filing complaints or lawsuits or other indirect mechanisms to spur designers or producers into action (e.g. Olsson, 2004; Bovaird, 2007; Pollock, Williams, & D'Adderio, 2007). We also do not include general theories of sociomateriality or post-human sociology (e.g. Dant, 2005; Latour, 2005) as these theories do not address directly and in detail first-hand engagement with the material qualities of product or services or with peers.

In the course of the article we seek to refer to people using products, services and systems with the specific terms used in different typologies or those adequate in the empirical context discussed. To avoid overly cumbersome sentence structures we do occasionally use the notion of 'user' as a generic term, in the way it is widely used in design, IT design and innovation studies, referring to people who use products and services to benefit from them directly (or indirectly in cases of secondary and tertiary users, i.e. people impacted and implicated by product use), without having to sell the service or good to others to do so (von Hippel, 2005, 2016; Redström, 2006, 2008; Oudshoorn & Pinch, 2003).

With the above in mind, let us move to examine more closely the typologies of active use and users' design engagement that have been advanced. Let us first recount a set of well-cited, simple one-axis typologies that address the continuum from passive use to what authors have considered as the most active engagement with design-in-use. This helps firstly to see some clear commonalities across different terminologies and, just as importantly, how the

terminologies imply different dimensions of what the people are 'active with' regarding design. Once these basic parameters are in place we can cross-compare and provide a first synthesis of the typologies.

In **design studies,** research in co-design seeks to understand, foster and manage user participation to strengthen design capabilities (e.g. Baek, Kim, Pahk, & Manzini, 2018; Bødker et al., 2004; Ehn & Kyng, 1992; Sanders & Stappers, 2008). Its particular foci have been in understanding the differences between how professional designers and lay people engage in design (Sanders, 2006; Taffe, 2015) and how professionals can capacitate lay people to design more widely and deeply (e.g. Bødker et al., 2004; Simonsen & Robertson, 2012). There has been increasing recognition of growing design competencies among co-design partners, which affects how they then can and should be best aided (e.g. Botero & Hyysalo, 2013; Hillgren, Seravalli, & Emilson, 2011; Marttila, 2018; Sanders & Stappers, 2008). Following Henderson and Kyng's (1992) seminal work on the advantages of continuing collaborative design after implementation, suites of design-in-use approaches have emerged, the most articulated being the co-realization approach (Büscher et al., 2009; Hartswood et al., 2002), meta-design (Fischer & Ostwald, 2002); the aging together approach (Botero & Hyysalo, 2013); and gradual system expansion strategies (Whalen & Bobrow, 2011). Probably the best-known typology in design research is Sanders' (2006) model of user involvement that has been adapted and expanded by others sharing the interest to identify opportunities for professional design practitioners to co-design with users (as "lay designers") in developing commercial products. Hermans (2015), for instance, has examined how users move from being passive and reactive to pro-active and more comprehensively engaged participants in the design of products, adapting Sanders' framework further as illustrated in Figure 1.

As noted in the introduction, design research has not been the first to pay attention to design activities by users. Since the 1970s, research on **user innovation** has been studying the ideas, prototypes, modifications and innovations that users have made in different industries and areas of consumer culture,

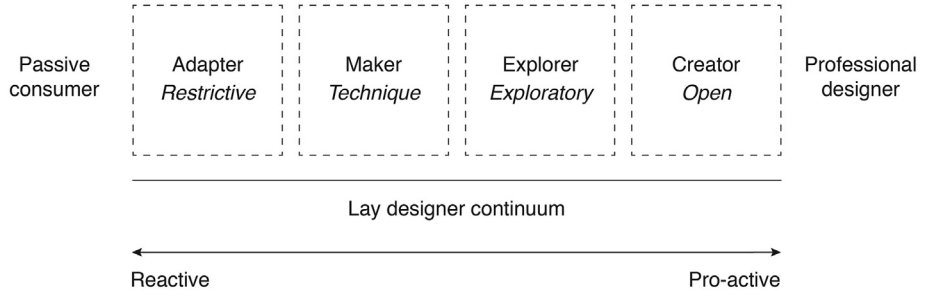

Figure 1 "Lay designer continuum" (Hermans, 2015, p. 157)

showing that not only professional designers and producer companies innovate, but 19–36% of studied industrial users and 1.5–6.1% of representative consumer populations in industrialized countries develop products for their own use (von Hippel, 2005, 2016; de Jong et al., 2015). To demarcate whether users have innovated or not in survey research, the differentiation has been whether users have *modified* existing products or *innovated* entirely new material solutions or techniques (de Jong et al., 2015; Hienerth, von Hippel, & Berg Jensen, 2014; Halbinger, 2018). When ethnographic access to each case has been possible, the schema has occasionally grown more complex, as in "routine use – repurposing – material adaptation – user modifications – additions by users – system wide designs by users" (Hyysalo, Johnson, & Juntunen, 2017; Hyysalo, Juntunen, & Freeman, 2013), but nonetheless anchored to what people do to or with designed objects.

Early attention to active use is also seen in **information systems and human-computer interaction** (HCI) research, where it has been discussed as part of IT appropriation since the 1980s, owing to observations of workers using systems only partially and integrating them with other software and physical means and settings to get work done (Alter, 2014; DeSanctis & Poole, 1994; McLaughlin & Skinner, 2000; Orlikowski, 2000). Regarding different forms of users' active engagement, the most thoroughgoing framework emerged already in the early 1990s as DeSanctis and Poole (1994) point to a range of "appropriation moves" that are common with organizational software. These range from appropriating as-is, to *substituting* the software use by other means, *combining* different software to achieve aims, *enlarging* the functionalities to new uses, *constraining* the use only to some aspects of the system, and *contrasting* software use with other means, each of which could be seen to pertain to the new design or to existing structures to which it links in the workplace. Further aspects of active use such as repurposive appropriations, creative uses and their situational and positional underpinnings have been further elaborated over the years (e.g. Hannukainen, Mäkinen, & Hyysalo, 2017; Liikkanen & Salovaara, 2015; Salovaara, 2012).

Just as importantly, **consumption studies** feature several categorizations related to active use, foremost among them being Campbell's (2005) differentiation among "cultural dupe, personalization, customization, craft consumption", which addresses both altering objects as well as the different *uses* and *meanings* and orientations involved. The domestication framework (Berker, Hartmann, Punie, & Ward, 2006; Silverstone, Hirsch, & Morley, 1992) in contrast draws out different aspects of active engagement with design through "appropriation – objectification – incorporation – conversion", where appropriation (understood narrowly) marks the economic shift in rendering a market good as one's own possession and into a non-commodity state (Kopytoff, 1986); objectification marks the integration of the good into the *physical context* and its existing orderings; incorporation marks how the functions of a good become

intertwined into users' functional purposes and related *functional meanings*; and conversion how the previously 'alien' good is converted to convey meanings about its owner in *interpersonal meanings* through expressions of e.g. wealth, style or dispositions.

Equally important are **Science & Technology Studies** (S&TS) frameworks, which also feature several widespread typologies, such as "Pre-inscription, conscription, circumscription and subscription, de-inscription and re-inscription" (Akrich, 1992; Latour, 1987), which point to the material form, setting and meaning being either being agreed or altered during use. More encompassing typologies regarding active use in the technology–user relationship are those by Pfaffenberger (1992, discussed in section 1.2.) and by Eglash (2004), who starts from reinterpretation, i.e. change in *meaning*, and continues to changing *use* and to changing *materiality* (Figure 2). Eglash emphasizes social power, marginalization, the black-boxing of technologies and citizens' strategies to change these power relations.

We summarize these fields' typologies in Table 1. The columns clarify the taxonomic categories, to what they refer and their limitations.

Taking stock of these distinctions, we see that these typologies explicitly move from what their authors regard as conventional consumption towards prosumption towards the right (when they are illustrated in a diagram) and aim at a better understanding of how people influence technology and product design during use. While there is some variation, these models suggest a set of distinctions regarding the *intensity* of active use. Whereas simply compiling the various suggested intensities would result in somewhat overlapping terms of 6–8 intensities, these can be analytically redacted to three distinct intensities in active use. In this 'axis' of degree of intensity, in addition to "use as-is" or use as implied in marketing, manuals and routinized use, there are three intensities of active use in the literature whose differences are important: "active and mildly adaptive use that involves tweaks of some kind", "locally innovative designs and modifications" and "new-to-the-world design, a.k.a. an innovation" (Figure 3).

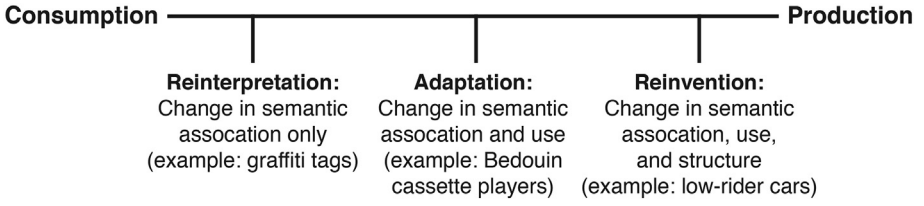

Figure 2 "The consumption-production dimension" by Eglash (2004, p. xi)

Table 1 Articulating users' engagement with design in key disciplines

Field	*Typology Categories, Key Referents*	*What Types Of Categories Are Represented*	*What Is Left Out*
Design studies	From reactive to proactive, Passive consumer to Professional designer: Adapter, Maker, Explorer, Creator (Hermans, 2015, expanding on Sanders, 2006)	Focus is on designing in relation to roles and creativity: from use as-is (passive consumer) to increasingly salient changes in objects and uses	Typology excludes changes in meanings, design settings and innovating
User innovation	Routine use, Repurposing, Material adaptation, User modifications, Additions by users, System wide designs by users (Hyysalo, Juntunen, & Freeman, 2013; de Jong et al., 2015; Hienerth et al., 2014)	Categories focus on design and especially innovation, from the object and use as-is (routine use) to increasingly salient changes in objects, local settings and new uses	Typology excludes new meanings and not-new-to-the world aspects of active use
Human-computer interaction	Direct appropriation, Substitution, Combination, Enlargement, Contrast, Constraint (DeSanctis & Poole, 1994)	From direct use of a technology structure to variations on its use and meanings and implying changing local settings	Typology focuses on designed software as an object that is not directly redesigned
Consumption studies	Cultural dupe, Personalization, Customization, Craft Consumption (Campbell, 2005); Appropriation, Objectification, Incorporation, Conversion (Silverstone et al., 1992)	Focus is on creativity and consumption as an activity with meaning: from use and object as-is (as a passive consumer) to increasingly salient changes in meanings, objects, local settings and to some extent uses	Typologies do not address differences between active consumption and locally new designs or new-to-the-world innovation
Science & Technology Studies	From subscription to de-inscription of form and meaning and re-inscription of material qualities (Akrich, 1992; Latour, 1987); From consumption to production: Reinterpretation, Adaptation, Reinvention (Eglash, 2004)	Focus is on the meanings and semantics of user engagement with objects, their settings and contexts, new uses and misuses, altering designed objects	Typologies do not differentiate innovations

Cross-comparison of the typologies further points to different aspects to which this 'degree' of intensity of active engagement may relate. Alongside change in "objects" (Figure 4, second row in the vertical axis), the changes can be about "uses" (Figure 4 first row), as is the case, for instance, in working around the product (Alter, 2014), technique innovation (Hienerth et al., 2014), or

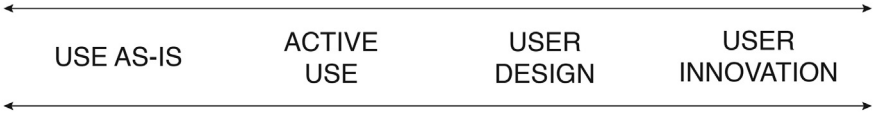

Figure 3 Summarizing the intensity of active user engagement with design and technology

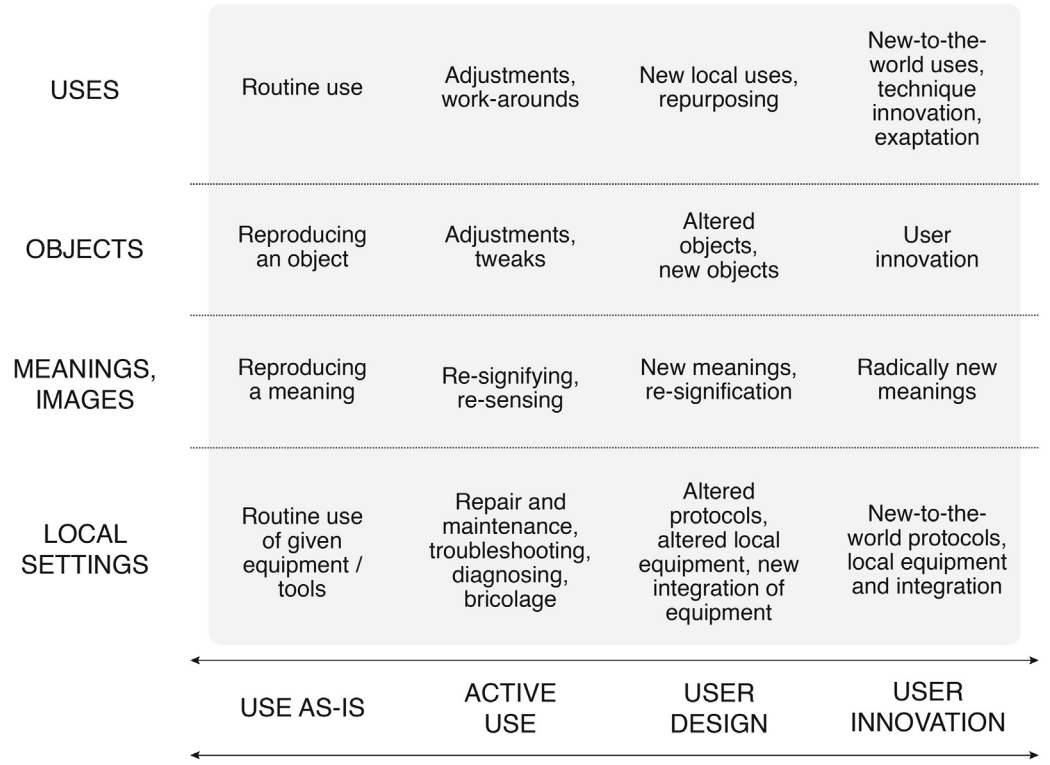

Figure 4 A minimal framework for discussing active design engagement in a given setting

exaptations, where a feature or product takes on a new function not originally intended (Andriani & Cattani, 2016). These are different from change in "meanings" (Figure 4, third row), as in new semantic associations (Eglash, 2004; Pfaffenberger, 1992). Consumption studies, design studies and S&TS also draw attention to user-made alterations to "settings" or in digital cases "local platforms" wherein a certain use happens to be in this home or that digital site (Figure 4, fourth vertical row). To clarify, from a perspective of actively engaging with design regarding uses, object or meaning, the local setting is setting-as-the-context. But when the use of a novel design leads to alterations in this setting-as-context to accommodate the design, the context itself becomes an object of design action. Such alterations can be found in intertwining novel designs in existing homes as documented in domestication studies (Berker, Hartmann, Punie, & Ward, 2006; Silverstone et al., 1992), in extensive repair and do-it-yourself practices at home where not only novel designs but surrounding spatial arrangements are altered (Shove et al., 2007), or bricolage, assembling and remixing elements to hand, in digital and physical settings (Büscher, Gill, Mogensen, & Shapiro, 2001). Hence, to dispel a fair amount of confusion over different typologies, and to make analyses more precise, we propose, in Figure 4, a **minimal taxonomic framework** for discussing active design engagement.

1.2 Collective forms of active design engagement: their increasing impetus and visibility through digital connectivity

The minimal framework built on previous typologies in section 1.1 remains too individualistic with respect to how some users, makers and prosumers engage with design. Various forms of peer networks and collectives increasingly design and produce products and technologies (or even urban interventions or social services) for their common use, forming activities of user design and user innovation (Baek, Kim, Pahk, & Manzini, 2018; Halbinger, 2018; Kohtala, 2017; Ratto & Boler, 2014). Collective forms of users' active design engagement have long existed (e.g. Allen, 1983; Schiavone & Esposito De Falco, 2016), but their prevalence, forms, extent, impact and visibility to researchers have increased greatly with the rise of digital connectivity and availability of easy-to-use and share digital design tools (von Hippel, 2005; van Abel, Evers, Klaasen, & Troxler, 2011). Research that addresses the collective aspects of active use and design engagement is predominantly found in the intersections between the fields discussed in section 1.1, as well as going beyond a single axis, and we suspect this is because of the insufficiency of the available within-discipline typologies.

In the intersection of **design studies** and **human-computer interaction**, Botero et al. (2010) have outlined active user engagement in digital community design and associated supporting design processes that can be carried out either by peers or by professional designers or other service providers (Figure 5). The diagram splits into increasingly intensive social design forms (create workarounds, make social agreements, foster evolution in social practices) and increasingly intensive technical user engagements (integrate, personalize, aggregate/remix, assemble components, use modules and libraries to design, program new libraries).

Botero (2013) further expands the schemata to the temporal dimension, showing how the collective design space can extend to community- and practice-related aspects over time, through various design-in-use strategies (Figure 6).

Similar findings of users' and makers' active engagement extending to building and maintaining communities and organizations, their routines, social practices, rules and procedures, emerge across disciplines (**information systems and HCI, design studies, user innovation** and **S&TS**), once researchers have studied various open design, open source and 'DIY maker' peer social groups (Kuznetsov & Paulos, 2010; Toombs, Bardzell, & Bardzell, 2014). These groups assemble in devoted open-access spaces, known as fablabs, makerspaces and hackerspaces, to use tools and equipment to design and make their own artefacts in community governance models that imitate modes established in Free/Libre/Open Source Software (FLOSS) development (Aitamurto et al.,

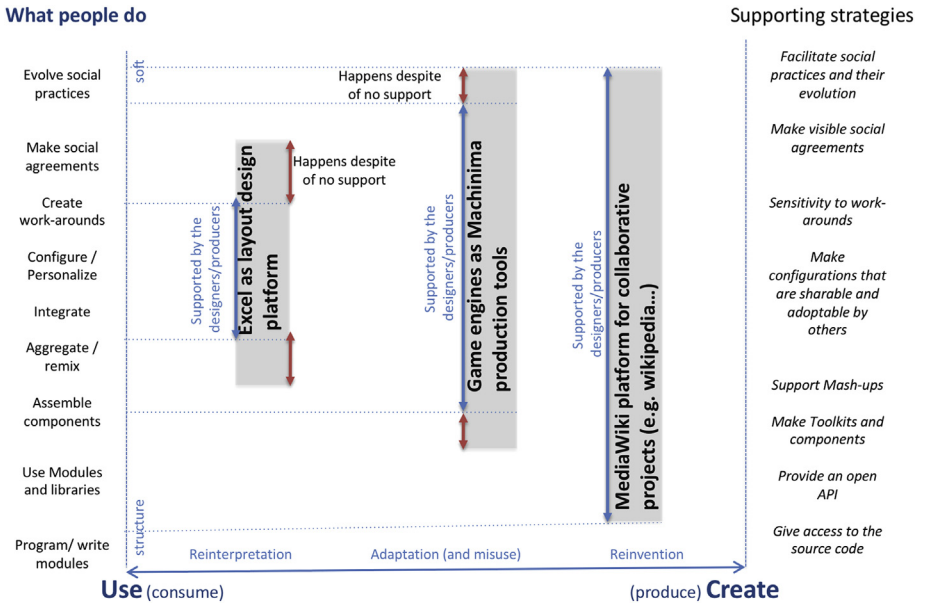

Figure 5 "Framework for a structure of the design space" by Botero et al. (2010)

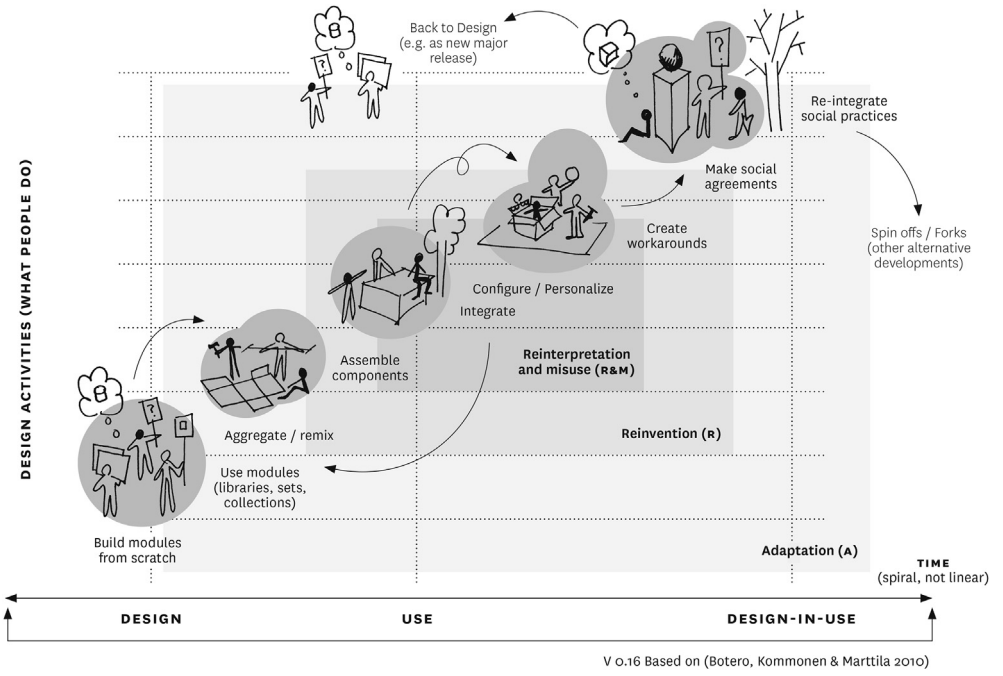

Figure 6 "Reinterpretation, adaptation, and reinvention in design spaces" by Botero (2013, p. 93)

2015; Marttila, Nilsson, & Seravalli, 2014; van Abel et al., 2011). In these open design initiatives, participants are involved in designing and sharing designs (Tooze et al., 2014; Özkil, 2017), as well as in altering the design of physical settings for their actions. Participants adopt a range of strategies to engage themselves in technology and product development, co-produce services and involve others in community work. Some of these engagements are routine, others introduce alterations and still others introduce new-to-the-world ways of acting. Building and maintaining *communities and organizations* becomes requisite for collective engagement with design (Aitamurto et al., 2015; (Bakırlıoğlu & Kohtala, 2019; Kohtala, 2017; van Abel, Evers, Klaasen, & Troxler, 2011). As in more traditional settings, peers mediate each other's design engagement through brokering contacts, facilitating learning and configuring systems (Hakkarainen & Hyysalo, 2016; Stewart & Hyysalo, 2008), and through acting as volunteers and community organizers (Johnson, 2013). Some act as "warm experts" from whom even 'stupid' questions can be asked (Bakardjieva, 2005) or "configurers" (Okamura, Orlikowski, Fujimoto, & Yates, 1994) more widely as "local experts" to whom members in a local community can turn for problem-solving help that is beyond the capabilities of themselves and closest circles of peers (Stewart, 2003). Such peer-to-peer and peers-to-communities actions are crucial for participants' control over the environment in which their design engagement takes place (Arnstein, 1969; Cardullo & Kitchin, 2018).

Once attention in **design studies** and **innovation studies** was drawn to collective design by peers, it became salient that a demarcation is also needed between the local settings and the wide, sometimes literally global, *platforms* which connect a wide range of local settings within a given domain (Benkler, 2006; Botero et al., 2010; Özkil, 2017; Usenyuk, Hyysalo, & Whalen, 2016). **Science & Technology Studies** underscore that altering and setting up trans-local settings takes place also in physical goods and more restrictedly available technologies such as proprietary digital services, albeit it then makes more sense to talk of *interaction arenas* than platforms (Hyysalo, 2010; Hyysalo, Juntunen, & Martiskainen, 2018; Johnson, 2013).

Science & Technology Studies goes further in conceptualizing the technology-mediated strategies of social control and the counter strategies. Pfaffenberger (1992) offers a typology that spans "regularization – counter significations – counter appropriations – counter delegation (non-use, modifications, hacking, reuse) – reconstitution". In this schema, reconstitution means actively reshaping technological production processes or artefacts guided by a self-consciously 'revolutionary' ideology such as that seen in much of the open and free software movement, the open-design, collective production of "counterartefacts" such as Linux or Mozilla Firefox that are free of the dominant industrial regime and its regularization strategies (Corbett, 2012; Kohtala, 2017). These ideologies are co-created and are similar to sociotechnical

'imaginaries', a group's or society's collectively held vision: a shared understanding of what it aspires for science and technology (Hyysalo, 2006; Jasanoff & Kim, 2015). Successful reconstitution of a sociotechnical imaginary involves the alteration, design and innovation of both objects and symbols, not only in creating counterartefacts, but also "counter-contexts" (Pfaffenberger, 1992). Reconstitution strategies can be readily observed in how alternative forms of production come to be taken as the only legitimate one in the organic food production movement (Durrant, 2014); community energy initiatives (Hyysalo, Juntunen, & Freeman, 2013; Nielsen, 2016; Smith, Fressoli, & Thomas, 2014); and subculture communities such as anarcho-syndicalists or design-oriented movements such as alternative hackerspaces and espousedly "green" makerspaces (Jeppesen, Kruzynski, Sarrasin, & Breton, 2014; Smith, 2017; Toupin, 2014). The *ideology* or *imaginary* motivates these collective endeavours, but is also reworked and altered by active users during the process (Flichy, 2007; Gregory, 2000; Jasanoff & Kim, 2015; Kohtala, 2017; Stein, 2017).

Table 2 summarizes the focus areas and limitations of the typologies summarized in this section.

These considerations imply added dimensions, interpersonal and translocal, to active use and design engagement. We add these dimensions to the minimal framework (Figure 4) and incorporate them into Figure 7 as Communities and Organizations, Imaginaries and Ideologies, and Global Platforms or other between-setting interaction arenas. To better appreciate how people engage in these different intensities of active use, and how we examine and analyse it in different dimensions, we discuss them through a concrete illustration in the following section.

2 *Peer-to-peer open design communities*

The distinctions in the taxonomy, showing the intersection of levels of intensity with dimensions of active engagement, can be illustrated through real-world examples from a particular domain, that of fablabs. We base our discussion on the empirical materials gathered during a four-year ethnographic study by the first author (Kohtala, 2016, 2017). The open design groups we studied often collaborate in shared community workshops called fablabs equipped with small-scale, digitally controlled production equipment such as milling machines and 3D-printers. These people, often called makers, are thus prosumers, both producers and consumers: they engage in object design (designing and making physical artefacts), as well as community design (designing events, interactions and community governance models). In such horizontal peer-to-peer arrangements, the boundaries between 'designer', 'user' and 'organizer' are fluid and shifting. In addition, the fablab settings

Table 2 Articulating collective forms of users' engagement with design in key disciplines

Field	*Typology Categories, Key Referents*	*What Types Of Categories Are Represented*	*What Is Left Out*
Design studies, Human-computer interaction, Consumption studies intersection	Build modules from scratch, Use modules, Assemble components, Integrate, Configure/Personalize, Create workarounds, Make social agreements, Re-integrate social practices (Botero, 2013)	Focus is on how users engage in design to strengthen and innovate collective aspects of practices in communities: altering elements of practice in community work to forming new community procedures	Typology does not address ideology explicitly, addresses global platforms only partially
User innovation, Science & Technology Studies intersection	Local settings, interaction arenas, global platforms (Benkler, 2006; Johnson, 2013; van Abel, Evers, Klaassen, & Troxler, 2011); Brokering contacts, Facilitating learning, Configuring systems (Stewart & Hyysalo, 2008)	Focus is on how users facilitate and configure for each other in communities: from intermediating in community work and social learning, to configurers of practices, organizations and global platforms	Typologies do not address ideologies, address only some processes within communities and organizations
Science & Technology Studies	Regularization, Counter-significations, Counter-appropriations, Counter-delegation (non-use, modifications, hacking, reuse), Reconstitution (Pfaffenberger, 1992)	Categories' intensities increase from actively resisting the dominant imaginary (and uses, objects and meanings) to immediate changes and innovations in imaginaries, community identities and collective practices	Typology does not address global platforms

bridge both physical, tangible materials and digital artefacts and infrastructure.

Let us first examine the basic dimensions of active design engagement (elaborated above in Figure 4), using specific examples observed in fablabs (Figure 8). There are various ways people want to USE a fablab. When using its equipment, a 3D-printer, for instance, they simply **use** it **as is**, as routine use, to print out an existing design file. When they make a few easy tweaks and adjustments, playing with the speed setting and changing the existing print procedure, this marks **active use**. Some have used printers in a new way, setting them up on hydraulic lifts, for instance, to print bigger objects, which requires design work beyond what is done in a moment, or **user design**. Some makers engage in technique innovation and new-to-the-world uses, using the printer to print in another material such as porcelain, as **user innovation**. Innovation by exaptation has also diffused to many fablabs: participants commonly use video game devices for motion sensing (such as the Xbox Kinect) as 3D-scanners, to create 3D models.

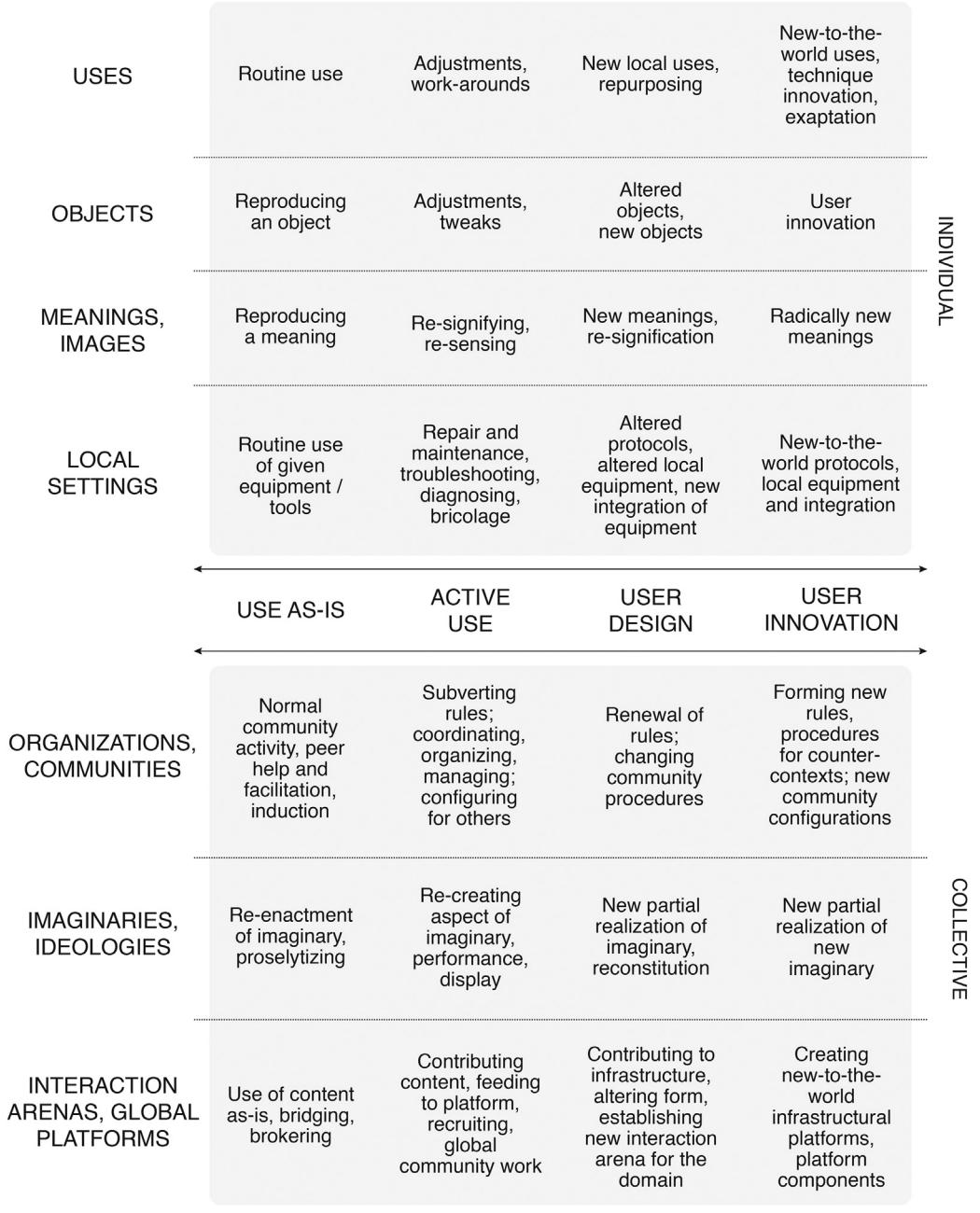

Figure 7 Varieties of active design engagement

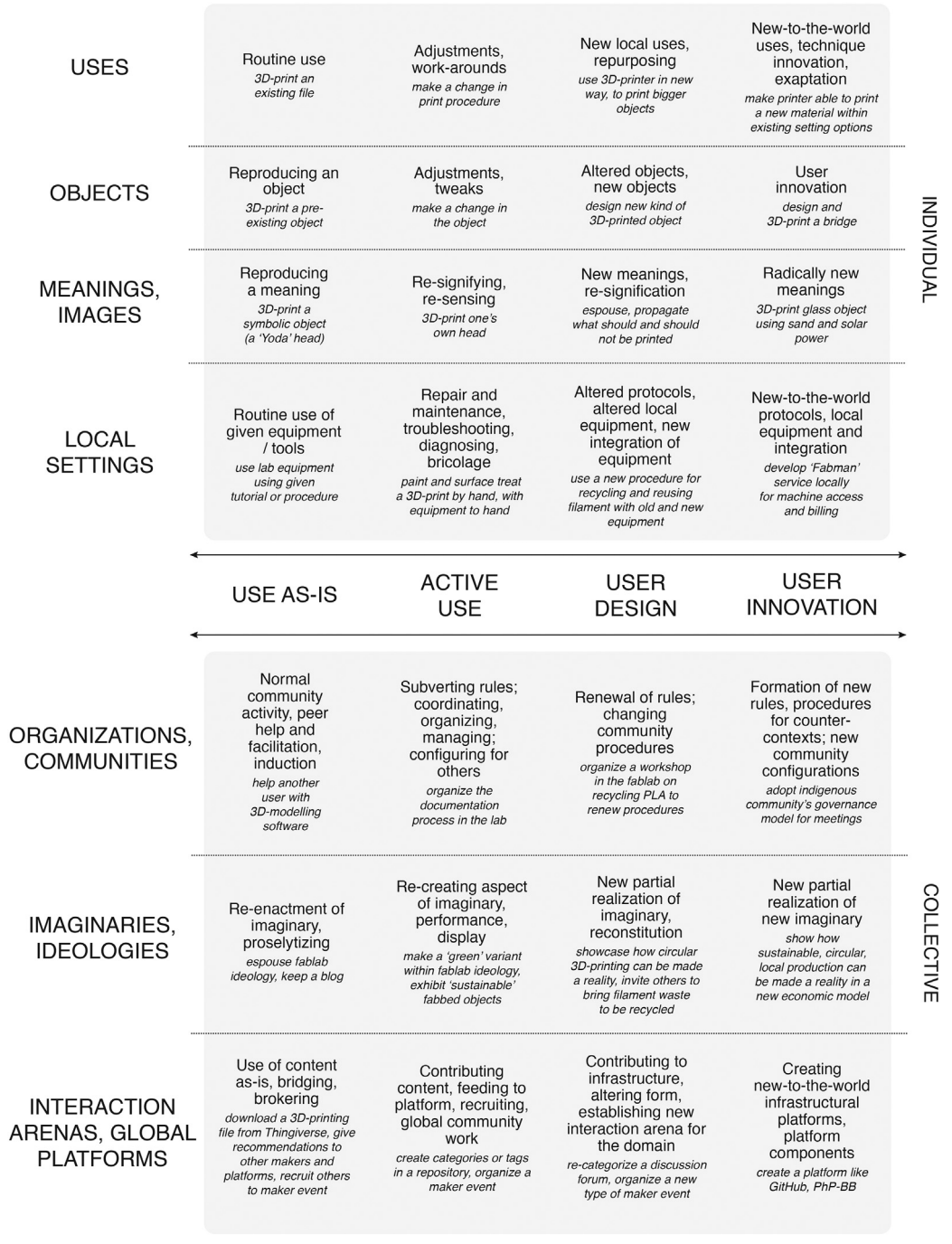

Figure 8 Varieties of active design engagement in peer-to-peer open design initiatives

When examining OBJECTS, such as 3D-printed artefacts, people simply **use** the lab, **as is**, to 3D-print a pre-existing object. When they actively tweak the object, this is **active use**, making a change in the object to personalize it in some way. Many start from scratch and design a new kind of 3D-printed object, **user design**. Some have innovated by creating new-to-the-world objects such as a 3D-printed bridge, which would be **user innovation**.

Beyond uses and objects, S&TS and consumption studies have shown us how people associate MEANINGS AND IMAGES with actions and interactions, which serve to legitimize them (see section 1). Many first-time fablab visitors, for instance, simply 3D-print an object, such as the ubiquitous head of the Yoda character from Star Wars which acts as a 'geek' symbol in maker culture. Someone just using the lab in this way (**use as-is**) is reproducing a meaning. Some participants 3D-print their own head, actively using the lab to explore the meaning of the activity for themselves, by re-signifying and re-sensing (**active use**). Some participants seek to redefine the meaning and purpose of 3D-printing, becoming ethically careful of what they print; printing a Yoda head, for example, is espoused as a wasteful result ecologically, with these participants giving new meanings for 3D-printing activities and re-signifying them in their lab communications and charters (**user design**). Other participants have created radically new meanings concerning the role of 3D-printing, for themselves (and possibly the wider community as well), such as producing glass objects using sand and the sun with a solar-powered 3D-printer (Kayser, 2011) (**user innovation**).

Turning to a fablab as a LOCAL SETTING, people just using the lab engage in routine use of the given tools and equipment and use a given tutorial or procedure (**use as-is**). Some participants use the given tools and materials but, for example, aggregate, remix and assemble materials and components or undertake repair and maintenance, troubleshooting or diagnosing tasks. Repairing a piece of equipment or painting or surface-treating a 3D-print by hand, with equipment to hand, for instance, suggests bricolage (**active use**). **User design** is another level of intensity that involves altered protocols, altered local equipment or new integration of equipment, such as the examples of makers using new procedures for recycling and reusing 3D-printing filament, with old and new equipment including office paper shredders. **User innovation** involves new-to-the-world protocols, local equipment and integration. Several examples in fablabs are locally developed digital applications for machine access and automizing machine time billing. 'Fabman' is one such service, which has also been more widely adopted by other labs globally.

We have now illustrated all sixteen types of use as-is and active design engagement in the minimal framework as seen in Figure 4. As we alluded in the examples above, the intensities of engagement can vary by the degree to which collectivities, groups of people or social movements adopt or co-create

alterations, designs or innovations. Fablabs are not digital-physical manufacturing services: people join them in order to join a community. They engage in design and designing that is socially oriented, as discussed in ST&S and design research (as in section 1 and Figure 5).

Any fablab therefore also has a role as a COMMUNITY or ORGANIZATION with particular practices related to rules, governance, identity and collective procedures (Figure 7). Using 'community' as a lens to examine active design engagement, people using the lab as-is engage in normal community practice by adhering to the lab's rules, routines and culture. Many engage in peer help, facilitation and induction by, for instance, helping others with 3D-modelling software as routine community activity (**use as-is**) (see Figure 8). The next level of intensity entails subverting, breaking or bending a rule in the lab; altering a procedure; or organizing, coordinating or configuring for others. Some participants, for instance, take the initiative to organize the documentation process in the lab (**active use**). Local designing in and for the community is also common, renewing the procedures or rules by, for instance, creating their own house rules for the lab. A group who wants to change community procedures, to orient the community to more environmentally conscious practices, might organize a workshop on e.g. recycling PLA filament (polylactic acid, a bioplastic) instead of sending it to landfill (**user design**). User innovation for the community means introducing a new-to-the-world element into the community or into the practices that constitute it (**user innovation**). An apt example of organizational innovation is the adaptation of local indigenous communities' governance models for meetings in the lab, to counteract dominant but undesired processes for decision-making inherited from a largely white, male, global North engineering tradition (Neale & Hobern, 2017). In the example of recycling PLA, user innovating for the community has entailed new community configurations: recruiting others into open innovation practices, with free sharing of equipment designs and instructions, steering of material flows towards circularity and offering space for experimentation and new revenue streams.

As indicated in section 1.2, Science & Technology Studies has emphasized how some communities operate akin to social movements, who co-create, use and adapt IMAGINARIES AND IDEOLOGIES, visions of desired futures that are publicly performed to align strategic partnerships, mobilize participants and muster resources (Jasanoff & Kim, 2015; Kohtala, 2017; Stein, 2017). In this category, a participant simply re-enacts an imaginary when she e.g. keeps a blog that conveys ideological content to others: proselytizing (**use as-is**). Some participants emphasize an aspect of the ideology they value such as ecological issues, by making a 'green' variant within the fablab ideology, or through performance and display, exhibiting 'sustainable' fabbed objects in the lab (**active use**). Some have begun to more intensively realize this new aspect of the imaginary, showing how circular 3D-printing can be made a

reality by showcasing the lifecycle of 3D-printing bio-based filament to the community, inviting others to bring 3D-printing filament waste to the Lab to be recycled and conveying the new aspects through symbols and objects (**user design**). Moreover some fablab collectives are showing how sustainable, circular, local production can be made a reality in a new economic model involving their own local currency. This involves creating a new partial realization of a *new* imaginary for peer-to-peer open design: a **user innovation** of an imaginary, which is paired with collective experiments in the lab and discursive items such as manifestos, displays or texts.

Finally, fablabs are not isolated spaces physically either; they rely on networks of connections to infrastructures and other local communities in the global DIY maker world. Examining **use as-is** of a lab in the framing of INTERACTION ARENAS AND GLOBAL PLATFORMS entails simple use of content: straightforward download of a 3D-model from an online global file repository such as Thingiverse, participating in interaction arenas such as maker events, or giving others recommendations about platforms or arenas. **Active use** entails contributing to the platform by, for instance, creating new categories or tags in a repository or recruiting and doing community work in organizing a cross-setting maker event. **User design** means altering the form of the platform or establishing a new interaction arena for the domain: fablab participants have, for instance, altered and re-categorized the online discussion forums for the global community and have organized new types of face-to-face, cross-setting maker events. **User innovation** implies creating new-to-the-world infrastructural platforms or platform components such as GitHub (an open version-control development platform for collaboration) and PhP-BB (free and open source forum software) (See Figure 7.).

In sum, peer-to-peer open design activities present rich terrain for demonstrating active use and engagement with design by non-professionally trained and hired designers. This richness may be extraordinary given open design activities feature shared, common design work, alternative new production networks, technologies, physical settings, platforms of global reach and various ideological currents that animate users' endeavours. Nonetheless, European fablabs exemplify active use and design engagement across all four levels of intensity of engagement and in all seven categories, detailed with examples in our taxonomy in Figure 8.

3 *Discussion and conclusions*

The wide spread of hacking, making, (re)designing and innovating done by adopters of designs underscores that important contributions to designs and designing are not limited to those made by professional designers in their offices. Just as importantly, design approaches that purposefully continue design during the use time with inputs from both users and designers – in academic

settings approaches such as meta-design and co-realization (Giaccardi & Fischer, 2008; Hartswood et al., 2002) and in industrial settings most notably minimum viable product strategies (e.g. Johnson, 2013) – emphasize the importance of the minor and major adjustments, locally new designs and added innovations people make to the offerings.

This practical relevance of active use finds its counterpart in several academic disciplines that empirically investigate the related phenomena from different vantage points. Yet as we have elaborated in this paper, most research, and resources available to practitioners, operates in simple typologies that are detached from each other and consequently neglect aspects and intensities of active use that are well established in others. Disciplinary conveniences have not equalled thoroughness, let alone empirical adequacy and usefulness. At the same time, a strategy to simply add up the disciplinary typologies would result in a muddle of potentially over one hundred different, partially overlapping terms and intensities of active use. The overarching finding across this paper has been that a more analytical and encompassing view, a taxonomic framework synthesis, of active use and design engagement is needed for both empirical and conceptual reasons.

We have hence analytically integrated the major differences into three crucially distinct intensities and seven areas in which active use can happen. Such an encompassing taxonomy is empirically relevant for understanding what people do in and with designs in the 21st century. We have illustrated that in digital-physical peer-to-peer open design initiatives, all forms and intensities of this more encompassing taxonomy are present, and the existing research shows that many of these forms are present in other contexts as well.

This taxonomy of 21 types of active use is valuable in orienting empirical researchers and practitioners to the forms, differences and interrelations within active use. It suggests distinguishing at minimum four individual aspects of active design engagement: with uses, with objects, with meanings and with settings. It further suggests minimally three distinct intensities beyond "use as-is", namely "active use", "local user design" and "new-to-the-world user innovation". This minimal taxonomy presented in Figure 4 is sufficient in most individually used designs, which are not opened to collective design engagement. We have thus purposefully kept the individual and collective forms separated in Figures 4 and 7 to ease the applicability of our taxonomy in those settings and research aims in which collective aspects do not feature importantly.

At the same time, the collective forms of active design engagement are on the rise, and as we illustrate through open design maker practices, examples can be readily found also in all forms and gradations of collective design engagement – in community and organizational form and practices, in ideologies, and in wide platforms – and these categories are important in guiding researchers

and practitioners to the full scope of active use in those settings where collective engagement with design is salient.

This more encompassing view on active design engagement draws attention to issues that various research communities have had a propensity to ignore. Let us examine the most salient implications as per the literature streams reviewed in section one, in the order we reviewed them, and end with an overall summary of implications.

For **design and designers**, the encompassing view on active design engagement should make clear that in most contexts design is not only, and often not even most importantly, about intended use but what 'users' make out of it in their real-life settings and practices. This calls for considerations on how tightly and loosely scripted different aspects of design are and what kind of access and ease is built into altering it: i.e. what meta-design strategies need to be adapted also in products and services that do not aim at fostering meta-design (Giaccardi & Fischer, 2008). The findings thus further underscore the importance of design-in-use strategies in design and development. People regularly alter and innovate the meaning of designed products and services, and when they pool their competences and resources they can achieve results equal or even greater to professional designers (cf. Baldwin & von Hippel, 2011; von Hippel, 2016; Hyysalo & Usenyuk, 2015; Halbinger, 2018). This undermines ideas where proactive engagement or the alteration and innovation of meaning would be the distinctive skill of professional designers – as suggested for instance by the widespread typology by Sanders that moves from consumer, adapter, maker, explorer, creator to professional designer – and more generally calls for further research on what the distinctive differences actually are between professional designers and designing users when the scope or quality of achievable design engagement does not seem to set maker and prosumer *collectives* inferior to professionals. Our taxonomy is further instrumental in pointing out muddles and blind spots in typologies such as the Sanders typology that mixes active design engagement in uses, objects and meanings in its 'continuum'. There is simply wider empirical ground laid out by 'lay designers', which can inform design professionals and design researchers.

For both **studies of appropriation in information systems and HCI** and for **consumption studies**, the more encompassing view flags the need to place the most intensive forms of active design engagement more firmly within their view of consumption and use. These bodies of literature tend to – similarly to tendencies in design research – lump together different forms of active use and local user design as evidence of active appropriation and not to further investigate the intensity of the design engagement in its different dimensions: have there been innovations and, if yes, then precisely in what. In addition the added clarity and analytical sensitivity provided by our full taxonomy should help HCI, information systems and consumption studies researchers to

address the increasingly complex patterns of prosumption, hacking, remixing, making (and so on) which they encounter in both digital and digital–physical settings.

Our taxonomy further implies that **user innovation** is not only about objects, techniques and exaptations, which have been the focus of user innovation research to date. Innovation by users can concern just as importantly local settings, meanings and organizational innovation. Even as these are much harder to measure, they constitute core elements that make free innovation thrive and that are necessary for its freedom (cf. von Hippel, 2016). An example of the potential bias this may set can be found in our own study of small-scale renewable energy technologies in Finland (Hyysalo, Johnson, & Juntunen, 2017; Hyysalo, Juntunen, & Freeman, 2013). Only when reconsidering the case material in light of the taxonomy built in this paper did it occur to us that many people were innovating and making modifications in their own settings, in how their whole home was set up anew. We had not conceptualized it as a cluster or system of small user innovations; rather we limited ourselves to listing user innovations in products and uses. There are thus likely gains to be made in developing more encompassing ways to record different types of innovations by users, and this is likely to require on-site acquaintance with innovators rather than via survey questionnaires.

Related to the above, our findings recapitulate **science and technology studies**' long insistence on technologies being comprised of more than just products, services or things. Technology use happens intertwined in practices and settings that are rich with artefacts and infrastructures, tied into communities and organizations, and animated by ideologies and imaginaries (Eglash, 2004; Flichy, 2007; Pfaffenberger, 1992; Ratto & Boler, 2014; Woodhouse & Patton, 2004). In the course of engaging with designs, users may also actively shape these other aspects that are assembled in technology engagement.

Our taxonomy and its illustration with open design making practices opens up several lines of further research. Firstly, the literature-based and logically ordered taxonomy ought to be validated in further empirical research regarding the prevalence of the active use types in digital, physical, service and platform designs. Validation is still needed concerning any now-unaddressed intensities or aspects of active use that are so significant in some domains that they should be incorporated into the general 21-type active use taxonomy. As a corollary to this, specific application domains may wish to redact or expand some of the aspects and intensities of active use to aide practical application in empirical research or practice (akin to our individual/collective division to provide also a more simplified version); the current taxonomy provides a basis for doing so on a logically ordered and encompassing basis, rather than seeking to mesh the simplified typologies that currently abound.

To sum up, making visible the range of capabilities people currently have as users, makers, creators, prosumers and participants in collective design endeavours, when they engage in and with designs and designing, provides needed detail and nuance to research and analysis of design and technology. This in turn will support 21st century designers in articulating how they can buttress people's active design engagement.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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