Her Right to Tinker: Gendered Perspectives of Participation and Generative Justice in Indian Makerspaces

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Gender Perspectives on the Digital Economy

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Her Right to Tinker: Gendered Perspectives of Participation and Generative Justice in Indian Makerspaces

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I. Background

As we progress towards an increasingly digitalized and interconnected world, collaborative innovation and open technology projects are gaining significant attention as venues of alternate value creation. Makerspaces are at the forefront of such open design aspirations, creating opportunities and interventions in community-based production and knowledge-sharing landscapes. The creative practices and the pathways toward democratizing innovation that these makerspaces envision have attracted substantial discourses in Human-Computer Interaction (HCI) design and peer-production research. This section briefs about makers and the culture of making. Makers are broadly defined as people "who tinker, fix, recreate or assemble objects and systems in creative and innovative directions, commonly adhering to the search for alternative and non-deterministic pathways to living in contemporary material worlds" (Nascimento & Pólvora, 2018: 930). The culture of making has led to the emergence of many organizational avenues with varied nomenclatures such as makerspaces, hackerspaces, co-working spaces, FabLabs, and so on. More often, all such terminologies of collaborative spaces for innovation are studied interchangeably. Whereas traditionally, hackerspaces denote community spaces that focus on software programming and experiments with electronic equipment (Cavalcanti, 2013), makerspaces, as a term, gained popularity with the Makers movement of the 2000s that advocated for making things to express the individual self and for learning by doing. Shifting away from the user-centric designs and propriety restrictions, the Makers' movement primarily aimed to bring in a transformative culture of sharing, learning together and providing community access to right tools for innovation (Hatch, 2014) These spaces encouraged individuals to collaborate for designing, creating, or simply, 'making' anything that is expressive of the creative self. Aligning with the digital era, both in India and worldwide, these makerspaces are now providing sophisticated equipment and prototyping possibilities, and thus are redefining the practices of collaborative innovation. From an organizational perspective, Capdevila (2014) differentiates makerspaces from other

corporate spaces and FabLabs, for the former's 'bottom up' approach of centering 'self-managed' individuals and communities as key actors in the countercultures they produce. While makerspaces also engage with the visions of the hacking community, Nyugen et al. (2021) observe that the term 'hacking' and the associated computing culture have always taken a masculine route regarding the values and cultures that they create and redefine. Throughout the paper, for the sake of simplicity and to avoid the masculine connotations associated with the term 'hacker,' I have preferred the usage of the word 'maker' to represent someone who creates and innovates in a community-based participatory culture (and that includes hackers, tinkerers, and maker-entrepreneurs).

At the outset, the various services and facilities offered at makerspaces promise a grassroots level of 'permissionless innovation.' That is, the collaborative practices of these spaces are guided by the idea that any technological innovation, by default, shall be permitted unless it causes serious harm to individuals and society (Thierer, 2016). With this principle, policies and institutions are expected to pave the way for technological progress with a compassionate 'tolerance towards the unfamiliar and the eccentric' creative individuals (Mokyr, 1992, p. 182). In exhibiting their creative freedom for technical innovation and social change, makers are distinct from others who create and design. They, in a way, have come to realize that the machine no longer belongs to the creator, and that the 'soul' of their technical artifacts and computing (to borrow from Tracy Kidder's *The Soul of a New Machine*[2]) are being eroded for more exploitative corporate interests. The politics of corporate capitalism, according to Herbert Marcuse (1969), ties one "libidinally and aggressively to the commodity form." He says, "the need for possessing, consuming, handling and constantly renewing the gadgets, devices, instruments, engines, offered to and imposed upon the people, for using these wares even at the danger of one's destruction, has become a biological need." (Marcuse, 1969, p. 14). What then entails is a creative need that drives individuals to innovate outside the circuits of existing corporate structures. As venues for alternative computing and knowledge sharing, these makerspaces envision building, maintaining and developing creative technologies and

Kidder, T. (2011). *The Soul of a New Machine*. Back Bay Books.

possibly extending them towards non-proprietary settings through collective action and collaborative open-source projects (Williams & Hall, 2015;.Luis, 2020). It then gives scope for developers to work in 'highly parallel, relatively unstructured ways and without direct monetary compensation' (Weber, 2009).

While some accounts interpret makerspaces as sites for fostering technological self-efficiency (Carbonell, Andrews, Boklage, & Borrego, 2019) and co-learning (Lindtner, Hertz, & Dourish, 2014; Hira & Hynes, 2018), and as places where people can 'balance hope and precarity, agency and marginalization' (Ames, Lindtner, Bardzell, & Bardzell, 2021, p. 10), other studies in Human Computer Interaction and innovation ecosystem elsewhere reveal a distressingly increasing tendency towards labour precarity in these spaces (Hardey, 2020). While these trends can lead to inquiries about the prevailing generalist visions of democratizing innovation, the perpetuating presence of exclusive infrastructures, technologies and hierarchies of masculine culture in these spaces, urge more feminist interventions (Nagbot, 2016; Okerlund, Wilson, & Latulipe, 2021). In the Indian case, while makerspaces are an emerging trend, feminist and women-only makerspaces as a "spatial manifestation of a feminist hacker, maker, and geek culture" (Toupin, 2014, p. 1), as in the West, are remarkably absent. Therefore, studies on the dynamics of female participation in Indian makerspaces are almost non-existent. The lack of feminist spaces intrigues this research in seeking women's involvement and their right to tinker and 'make' in India. By conducting this research, intentions to address the classic feminist question of "where are the women" are carried forward with exploring the nature of social innovation outcomes in these seemingly inclusive spaces.

In paths aligning to the digital economies, we see that makerspaces that were once predominantly used as spaces for individual and hobbyist projects have now transformed to cater to electronics and robotic requirements. This trend encourages more makers to participate and create new innovative ways in product design and scaling up. However, as unique as it may seem, bringing new production techniques to knowledge economies, despite the emancipatory promises, poses a series of concerns. The practicalities of belongingness, inclusive accommodation, and individual freedom for creative work in any such technology space are decided mainly by bodily configurations and social positioning (Diamond, 2008). Do

they provide enabling infrastructures for making the ecosystem gender-inclusive? - this persistent question forms the basis of this paper. While the Western techno-optimistic imaginaries of development visualize a modern society with democratized access to innovation, how far have these open design spaces been able to achieve diversity and empower women's participation remains crucial to scrutinize, the attempt of which is carried out in this paper.

The remainder of the paper is organized into the following sections. The second section charts the objectives of this study, the research questions, and the methodology followed. Based on these questions, in the third section, an account of female participation, the feminist dialogues in the existing makerspaces, and the lessons for the Indian case are analyzed. In the fourth section, the concept of generative justice (Eglash, 2016), often brought forth in the discourses engaging with peer-to-peer economies, is placed within the reality of the Indian makerspaces. Following that, in the last section, findings and conclusions are derived for the Indian makerspace scenario, keeping the larger vision of feminist justice as the central point of the study.

II. Research Questions and Methods

The research was carried out with three broad objectives - (1) to study the extent of female participation and alternate forms of value creation in Indian makerspaces; (2) to identify the presence of feminist technologies and policy spaces, if any; and (3) to bring in the discourse of justice and personal agency in the entrepreneurial practices of these emerging innovation spaces. The questions that are sought to answer are as follows.

1. If techno-utopian ideals aim for participatory innovation in the digital sphere, how are the makerspaces in India providing a gender-inclusive place in the innovation ecosystem?

2. Are these makerspaces producing feminist technologies?

3. How are these spaces generating an unalienated value of labor?

Approaching via feminist standpoint theory that commits to engaging with the information and experiences that women want to narrate and be heard, I conducted qualitative, semi-structured interviews with twelve makers (eight of them identified as female and four identified as male) and ten owners of different makerspace settings (of which only four of them were female). All of the makers interviewed belonged to the age group of 18 to 35 years with varied employment statuses – four were engineering students, two identified as 'unemployed', and six were employed who were using these makerspaces to build on their side hustles. The spaces under study are established as ventures across the cities of New Delhi, Bengaluru (Karnataka), Pune (Maharashtra), and Chennai (Tamil Nadu). The sites were chosen through an exercise of purposive sampling, followed by snowballing to understand better nuances and experiences. The relational stance of the interviews came with the cognizance of different positionalities between the researcher and the environments studied. Lee Ann Fuji (2018), while emphasizing the importance of reflexivity in relational interviewing, quotes American journalist Charlie Rose who views interviews as at the "core of drama, fiction, [and] real-life." Interviews that I conducted stand testimony to this quote. The narrated experiences, their engagement with technology and society at large, their self-identification, and their aspirations have uncovered the many dramas of their zealous expeditions towards emancipation. With an awareness of ethical sensibility, Lee supports an interpretivist methodology in relational interviews that reveal the evolving worldviews of the interviewees through dialogues and interactions. Keeping that in mind, with what started via interview schedules of 60 to 90 minutes with each participant, I engaged with many follow-ups as informal interactions and active listening with the participants. That indeed established a working relationship with them. Their responses and opinions are documented here with anonymity.

The interviews were carried forward in the following directions. Initially, a primary demographic survey of how many women access these spaces, the dynamics of enrollment, and basic safety and gender-sensitive policies and amenities that these private spaces have, was conducted. These data were collected via interviews with owners and the public information that was put on their websites. Moving forward, interviews with the actual makers

and aspiring maker-entrepreneurs were conducted to capture two main ideas. One, is the maker's insights on the space she is put in. Apart from the makers' awareness of diversity and gender sensitivity in these settings, the questions of how inclusive she feels, how much creative freedom she experiences, and the various hurdles, if any, that stand in their way towards economic independence were drawn from their narrations. Two, their perceptions about policies that envisage nurturing the innovation ecosystem were asked. The interviews and their personal reflections were recorded and then analyzed.

III. Where are the Women?

This section provides a picture of makerspaces elsewhere (USA and China), and attempts to understand the emerging narratives of gender inclusion and the nature of feminist technologies that are produced. To seek answers to the first two research questions, this section situates the question of women's place on three grounds – firstly, their extent of involvement and presence in these physical spaces, then the sensitivity (or the lack of) provided in the policy and business scenario, and their influence in the type of technologies produced. Given that the Makers movement had started earlier in these countries, an inquiry on how far these spaces have fostered female participation in STEM education and entrepreneurial cultures will give the Indian case more lessons to learn and unlearn. In this context, the study aims to view the participation of makers who identify as females as a psychosocial attribute and attempts to scrutinize various socio-cultural settings and state policies that are crucial in driving feminist makerspaces. Furthermore, by studying the type of networks and communities that these female-identified makers are building, the pursuits of immaterial innovations and the prospects in the Indian landscape are considered.

Judy Wajcman (2004) verily opines that "the promises of emancipation from the frailties and failings of mortal flesh have reached a new crescendo in the cyberspace age." (p. 3). Observing western society, she sees that even when liberal societies commit toward gender equality and women's economic independence through 'flexible, temporary and contingent jobs' denied for centuries, the modern present carries the ghosts of the patriarchal past. Toupin (2014), in her

study of the makerspaces in the US, realizes that this persistent inequality is often structural, even when laws and policies are well in place. The Makers movement that emerged as an "American admiration for self-reliance and combines that with open-source learning, contemporary design and powerful personal technology" (Voight, 2014) has created a culture that countered the traditional means of creation in the consumer society. Even when these spheres have opened up places for all genders and intended to transform the prevalent socio-political and economic relations, gender hierarchies remain in these makerspaces with a predominance of male-created designs of technology. Contesting the male command in newer and liberating societies, many feminist and women-only makerspaces have been emerging in the US, with the first feminist hackerspace having been established in 2012 (Capel, Ploderer, Brereton, & O'Connor Solly, 2021). The *Geek Feminism Project*[3]*,* which started as an online forum in 2008 for women to share their stories of discrimination and sexual harassment, was one of the early volunteer-run initiatives to have initiated conversations about feminist spaces in the US. Since then, numerous makerspaces with agreed visions of intersectional feminisms have played a more prominent role in actualizing the creative self of feminists (Dunbar-Hester, 2018). By wanting spaces to remain 'responsive to their desired boundaries' (Sophie Toupin, 2014), the culture of feminist spaces stands distinctly apart from other normal makerspaces. In these places, community building, collaboration, and knowledge production modes are wide-ranging (Capel et al., 2021). While regular makerspaces provide access to a pool of technologies and opportunities to collaborate, feminist hackerspaces achieve substantial networking, and skills-sharing on creative techniques – from home needs to hacking. Most of these spaces produce labor that is immaterial, and that is both analytical and affective (Dunbar-Hester, 2016). They also took initial steps to break away from traditional homosocial reproduction and recruitment practices in the workplace, which mainly caused entry barriers for women in the innovation ecosystem barriers(Lewis, 2015). Realizing that technology, in itself, is not neutral and is an instrument of exploitation, most feminist makerspaces consciously commit to the ideals of intersectional data feminism (Hoffman, Bardzell, Fox, Menking, & Steinhardt, 2017; Sophie Toupin, 2014). They seek to co-liberate, primarily identifying that the existing power

[3] https://geekfeminismdotorg.wordpress.com/

structures hinder creativity and the social impact of technologies, regardless of whether men or women handle it. Feminists, when it comes to the computing field, are troubled by the fact that the emerging fields of Big Data and Artificial Intelligence are "deafeningly male and white and techno-heroic" (D'Ignazio and Klein, 2020, p. 9). While the initial intentions of feminist makerspaces are to create safe, accessible, and open spaces for women(Toupin, 2013), they have also succeeded in creating various forms of immaterial innovations, supportive networks, and, more importantly, feminist technologies that challenged the inherent male designs by imbibing feminist values in design (Fiesler, Morrison, & Bruckman, 2016). These include, say, innovations in cost-effective reproductive technologies and products that automate the daily care work of women. Furthermore, beyond diversity and feminist technologies, some makerspaces with female participants have progressed towards activism. This trend has been particularly remarkable in the US. Hacktivists, as they are called, have also utilized these spaces to bring political awareness and activism to the hacking culture (Taylor, 2005),uilding free and open software that challenges the prevalent cyberlibertarian sentiments of Silicon Valley(Dunbar-Hester, 2018). However, while we see cases of hacktivism that have led to civil disobedience and mass protests in online modes (Toupin, 2020), some scholars observe that the makerspace culture has primarily to do with personal gains, with the makers maintaining 'politically agnostic' distances (Coleman, 2018, p 187). They believe that although the culture of making has given way to the possibilities of unalienated labor value, the dismal representation of certain groups and the prevailing indifferences of established makers to reform the skewed gender dynamics have unfortunately kept the oppressive systems intact. On the other hand, even when specific policies and spaces consciously include women, certain spaces fall for meritocratic cultures (Nafus 2012), implying that whatever the ideals of 'democratizing innovation' (Hippel, 2005) that were envisioned have so far been falling short of inclusivity (Dunbar-Hester, 2020).

In the case of China, Silvia Lindtner, Anna Greenspan, and David Li have significantly contributed to the literature concerning the makerspace culture and the increasing impacts of mass innovation in Chinese society. Lindtner (2015) accounts for a unique culture of "hacking with Chinese characteristics" in these makerspaces. They draw boundaries between the

professional 'making' and the Western notions of making that are driven primarily by individual hobbyists' endeavors. She reveals that these innovation avenues in China, as a site of both technological and cultural expertise, thereby altering the computing convention that splits manufacturing and innovation along geographical lines. Her ethnographic study includes China's first hackerspace *XinCheJian,* which came into being in 2010 and later transformed into *XinDanWei*, the 'new worker units'. She finds that China's makers, backed by the party-states' mass innovation campaigns and aspirations, are creating their own articulations of ideologies and expertise, thereby hacking and countering the well-established Western copyright principles. Similarly, Kera (2012) finds that by going beyond the manufacturing cultures, these hackerspaces blur the division between lay and professional settings, thereby reconstructing the relationship between laboratory and society, and between facts and values. This means that makerspaces represent a desire for radical reform of the education system (Saunders & Kingsley, 2016). Wen (2017) further adds to the study by identifying how the phenomenal growth of makerspaces complemented the transition from the 'Made in China' campaign to the state's 'Created in China' campaign. There are five types of makerspaces identified in China (Saunders & Kingsley, 2016). They are the community hackerspaces similar to their American counterparts, hardware accelerators and incubators that the government mostly funds, Kids' education clubs, Open access university labs, and Makerspaces within corporate companies. Two-thirds of these spaces receive government support and funding. Since manufacturing is at the heart of the state's ambition, as evident from the *Made in China 2025* strategy[4], government speeches and writings that integrated manufacturing and making with entrepreneurship and innovation have been released since 2015. The party-state believes that this maker-culture has encouraged China to cultivate an attitude of self-making and self-entrepreneurship, thereby envisioning to help democratize innovation and technology (Lindtner, 2017). On that line, calls for 'self-directed innovation', 'indigenous innovation', and creative industries with a division between *wenhua shiye* (cultural institutions) and *wenhua chanye* (cultural industries) come into discourse. The State Council has also published a Guideline on Emerging Sectors of Strategic Importance During the 13th Five-year Plan Period

[4] https://english.www.gov.cn/2016special/madeinchina2025/

(2016–20) (General Office of the State Council, 2015), for 'digital creative industries' that sought convergences between digital technology, culture and creativity, and design. It also intends to create a digital platform for innovation and entrepreneurship. Despite the pervasive belief that digital technologies provide new opportunities that can lead to socio-economic mobility, these makerspace countercultures and their rising place in Chinese society have given rise to further problems. The promise of innovation, on a massive scale, has led not only to an overworked generation of workers but also has created racial bias from the western eyes, hyper-feminization of work culture, and labor precarity as these self-made entrepreneurs and workers are not promised any social security benefits (Lindtner, 2020). Thus, it is at the erasure of differences between the flexibility of work and precarity, that makerspaces continue producing imbalances that demand inspection. On the one hand, we see a state that has legitimized open-source in a peculiar form of assertive marginality (Graham, 2019), thereby disputing conventional intellectual property regimes. State policies of China that envision enabling the next era of informatization-driven industrialization signal 'entrepreneurial solutionism' even in informal spaces (Keane & Chen, 2017). On the other hand, domestic labor issues, the mechanism of exclusion and subversed gender norms are significant problems in the Chinese mass innovation ecosystem. Studying digital labor, thus, is crucial to understanding the changing norms of Chinese society that are driven by innovation. A traditional communitarian ideal of circulation of value prophesizes that free distribution inspires free contributions. In contrast, the makerspaces of China indicate two trends – one, the intended outcome of these spaces is products that are likely to sustain by inheriting older structures of patriarchal and racist models. Two, due to various mechanisms of gender exclusion, peer production may fail to create technologies that are inclusively identified for the needs of everyone in society.

We now focus on the Indian landscape. Significant observations can be drawn by studying the cases of the US and China. Firstly, while the West has deliberated on intersectional principles in their established feminist spaces, countries like China and India lack an overhauling techno-feministic framework that may fit into their national cultures. Western feminist makers consider their spaces a step towards techno-revolution and attempt to break away from the

black-boxed masculine tools and technologies. Through conducting open workshops, conferences, and community gatherings outside work, these women keep the flame of feminist consciousness awake. While most US makerspaces are run by motivated and affluent libertarians, and the party-state progressively supports the ones in China, Indian makerspaces are constrained in capital and ownership patterns. Due to business viability and cost constraints, these makerspaces do not have women-centric concessions for the reasons of business viability and cost constraints. Neither does the state provide subsidies or incentives to the private makerspaces to encourage women's intake. Besides, there is silence when it comes to activism in India. In the US, and even China, we see instances of how makerspaces lie as venues for collaborative designs invoking public activists to innovate further for a social cause. Open innovation labs are found to break the boundaries between technology and individual philanthropy. Calling makers as 'change agents', Wang (2019) accounts how Chinese makerspaces, in collaboration with non-governmental organizations, aspire to participate in environmental activism and struggles for social justice. While most of these activists occur in digital spheres, confronting the party-state's ideals, especially when most of these makerspaces are state-funded, signifies how the western quest for individual freedom has impacted the youth of modern Chinese society.

In India, the interviews convey that while creativity and the imaginations for social transformation are abundant, activism and showing solidarity for the feminist cause have become an interest confined mainly to the universities. Firstly, with the data collected across these sites, we learn that on any given day, the number of female makers is less than 10 percent**.** This is the case even in established makerspaces with more than five years of operations at the heart of the cities. Furthermore, the notable absence of exclusive feminist spaces in India closes various opportunities for feminist designs and handholding workshops. A female maker-entrepreneur who was interviewed comments, "w*omen attend more workshops to learn the art of making but are hesitant to persevere in the making.*" The rest of the owners interviewed also expressed the same concern that while workshops have attracted aspiring women, there is a lesser transition seen when it comes to actual making and participation. Indian makerspaces expose a skewed ownership pattern, let alone participation.

Out of the fifteen makerspaces under study, only four of them were led by female founders. Three of these four female co-founders entered the scene as the maker-entrepreneurs' spouses. For ten of the fifteen female makers I interviewed, making was their side hustle.

As Judy Wajcman (1991) opines, technology and masculine culture always have been interlinked. Men's ownership and control of technologies and innovative spaces restrict women's inventiveness and creative processes, observes Wajcman. If that is the case, the narratives of openness that makerspaces claim to bring appear as futile promises. Production of feminist technologies, that is, technologies that serve a woman's need, is rarely the primary outcome of makers' creations. How does then, one imagines technologies based on women's values, if ownership by women is dismally negligent, remains a pertaining concern. Unless exclusive feminist spaces are in functional existence, as it was seen in the pockets of San Francisco, the masculine construction of technology may continue.

Zucker (2004) observes a trend among women who are reluctant to identify themselves as feminists yet aspiring to strive for an egalitarian society. Indian makers show a sign of this tendency. Out of the twelve female participants, only five identified as feminists. Two makers were college students, and the rest three were from the owners' cohort. The eldest of the maker-entrepreneurs interviewed, who has over twenty years of experience in mentoring and making, opines that makers' self-identification as feminists shall positively impact the participation and technologies produced. "*Unfortunately, our makers who are hustling part-time are comfortable with the label of homemakers rather than avowing their 'feminist-makers' spirit*," she says. Reluctance to identify as feminists, as Aronson (2003) recognizes, arises with their apprehensions towards the stereotypes associated with the term. But, how does a label matter in changing the patterns of involvement, one may wonder. While feminist technologies may not necessarily be produced by feminists, as observed in the cases of some reproductive technologies (Loh, 2005, p. 4), the knowledge production contesting heteronormative structures may be nurtured well in surroundings that have concrete feminist outlooks.

Active commitment to the feminist cause, either through various conscious behavioral patterns that they exhibit in the male-dominated society or through the trendsetting feminist

technologies they create and scale up, occurs at multiple stages of development (Downing and Roush, 1985). From a passive acceptance of the sexist reality around them to the revelation and struggle through self-learning, the feminist identity evolves into being. Makerspaces offer a chance for legitimate peripheral participation, where beginners grow and transform according to community settings (Lave & Wenger, 1991). Contrarily, by failing to nurture feminist conversations and communities of practice, Indian makers may be normalizing the existing realities. The purpose of feminism is to confront the current status quo in HCI, as Bardzell & Bardzell (2011) propose. Letting go of their conscious temperaments only to fit into male-dominated tech spaces is a problem that needs to be highlighted in specific Indian spaces.

Dunbar-Hester (2017) stresses the importance of 'geek' as a social identity as these communities "are situated between downstream end users of technology and upstream social groups like policymakers and designers." (p. 82). When such geeks are beheld with masculine identity, as it has historically been, dilemmas of identification with the feminist geek self emerge. With women "just doing their work" to create innovative technologies and not imbibing principles that would define their being, activism in makerspaces is rarely felt. Thus, from these experiences, we see the contradictory cultures that exist within the makerspace setups worldwide. Their liberal aspirations, openness, and equitable infrastructures of the makerspaces are questioned, regardless of the geographies of the makerspaces. However, specific to the Indian context is the question of feminist self-identification that has delayed the advent of exclusive feminist and women-only makerspaces as it is seen in other parts of the world.

IV. Talking 'Justice' in Tech spaces

This section attempts to deliberate on the gendered perspectives of the '*bottom-up circulation of unalienated value*' that is viewed as the basic principle of generative justice, as Ron Eglash aims to gain in such open-source and innovative spaces. According to Eglash (2016), unlike other patented forms, open-source cultures are a utopian idea of giving us the right to distribute and modify technology. While not discounting the existence of alienated labor in any

mode of capitalist production, even in the participatory peer production spaces such as makerspaces, he observes that even in "a messy, compromised form", there is an extraordinary potential for generative justice. The ethos of open-source cultures lies in the mandate "to identify under-represented groups and remove their barriers to access" (Eglash, 2012). Talking political theory of justice to people engaging with technologies, especially in the Marxian sense, is scrupulously crucial. Moving beyond the usual concepts of justice that envisions a 'distributive' goal, Eglash seeks justice that is 'generative' and that comes as a "*the universal right to generate unalienated value and directly participate in its benefits; the rights of value generators to create their own conditions of production; and the rights of communities of value generation to nurture self-sustaining paths for its circulation.*" (p. 382). This primary definition is taken for the gendered critiques of technologies produced in the makerspaces of India and is conceptually discussed here. It can be understood in ways as Eglash frames it – "addressing unmet social needs, offering new means of social critique, and new tools for resistance to intrusion or exploitation." (p. 387).

It is widely held that the design of technology will determine the structures of power and dominance in society, sometimes reducing us to become merely "passive onlookers" (Longino, 1987). However, one must also look at the other ways communities create technologies. Technologies can also be politically and socially relative, 'underdetermined by the criterion of efficiency and political interests (Feenberg, 2001: 189). Contesting this, makerspaces emerged with the need to handle such technologies cautiously and to transform societies. As a step forward toward building a post-capitalist community economy where the relationship between actors is democratically negotiated (Gibson-Graham, 2008), the outcomes of these spaces are expected to go beyond product-based solutions to reap more social benefits through impactful technologies. Computer-supported Cooperative Work (CSCW) enabled by makerspaces, thus, has two major benefits. One, they bring in participatory engagement and derive knowledge from many sites and method assemblages. Two, they break away from the patterns of dull, repeated routines of jobs that the corporates offer. But, how do these benefits translate to fulfilling feminist visions and justice? "*Most products for women are designed by men, don't you feel*?" asked a female co-founder of a makerspace, as it was an obvious fact that

has already been normalized. To understand how makerspaces and the products designed at these places are 'addressing unmet social needs', the makers, in their interviews, were asked how they felt the traditional assumptions and hierarchies of masculinized labor were changed through these non-professional makerspace settings. Ninety percent of the makers felt that these spaces have enabled transformation towards a participatory design that amplifies more value to the creator as equally as to the customer. However, marginalization of women in these settings exists even upon practicing democratic methods of training and access to tools. This happens in various levels of subtlety – "*right from being interrogated about personal lives during the marriageable age to just ganging up an all-men team for collaborative product designs*" – as one female maker accounted. With this, how would one then envision a feminist utopia where technology serves the larger interests of empowering women, one may have to contemplate.

Furthermore, inquiry demands the question of whether these tech spaces offer new means of social critique. Participatory design can potentially bring forth emancipatory politics and the recognition of societal problems (Bardzwell, 2014). These spaces have opposed the top-down models of power and the extractivism of mass production. But what is essential is the affective nature of collaborations that lead the way to feminist thinking. The essence of tools and technologies, as it is widely held, mostly lies in something outside the tool itself. Communicative ethics, as Benhabib (2013) envisions through a participatory design, "may supply our minds with just the right dose of fantasy such as to think beyond old oppositions of utopia or realism, containment or conflict". (p. 49). Newer ideas in feminist social critique shall then be an integral outcome of these spaces when all things are taken under the assumption that more women are involved as "real participants" with clear commitments instead of presenting themselves as disembodied and disconnected attendees.

As a final component of realizing generative justice, we now get into the technologies that come as tools of change and revolution. Certain technologies rightly termed "protest technologies" that challenge extractivist mass production and other oppressive effects of technologies, have been birthed through these spaces. Eglash (2016) cites the open-source prototyping platform *Adruino* as an example of peer production that has had upshots on counter-surveillance protests and gay rights activism. Thus, justice probably gets served not

only with the freedom from jobs but also with the creation of a social platform that voices various political needs of the time.

In this study, two progressive trends are observable in technologies produced and engaged by female makers in India. One is that girls, at an early stage, gain the confidence to tinker, code, and design technologies at state-sponsored tinkering labs established in higher secondary schools. From the interviews with the owners who have experience in mentoring, it is learned that makerspaces and tinkering labs present at schools and universities have encouraging impacts on aspiring maker-entrepreneurs. For instance, Interactions with the owners revealed interesting ideas from schools - such as wearable media objects, sensors to detect body temperatures, alarm clocks in piggy banks, LEDs that lit and danced to the tempo of the songs. Secondly, an increasing shift in interest towards newer technologies is being noted. All the makerspaces under the study, that were once a place that provided for wood-work, welding, and knitting, are now equipped with basic electronics, 3D printing tools, and other tinkering gadgets. Furthermore, technological expertise training and assistance are provided for entry-level participants. All ten makerspaces that were interviewed frequently conducted workshops to introduce newer technologies and offer mentorship and possibilities of mutual support. Hence, the transformation here is the entry of newer forms of tools that would help her envision technologies and the very behavioral change and confidence that she gains to dream, code, and tinker. However, actualization is a long way to go. Seven of the ten owners of the makerspaces interviewed hold that despite workshops and training likely attracting female participation, the number of women drastically decreases when it came to actual enrollment to utilize the spaces to innovate substantially.

V Understanding 'Her Right to Tinker'

From a legal perspective, Paul Samuelson (2008) charts eight criteria for the freedom to tinker. There are as follows - the intellectual freedom to engage with existing up-to-date technological artifacts, privacy and autonomy to experiment with these artifacts for a personal pursuit or for a commercial pursuit whatsoever, the freedom to improve one's skills, the freedom of

individual self-expression, the freedom to learn from tinkering, freedom to use technologies for purposes other than initially envisioned carefully, the freedom to innovate from the tinkering, and the freedom to share innovations and build communities optionally. The framework for this study considers the right to tinker as the right to freedom under the abovementioned aspects. In an ideal world, all these freedoms are to be sought irrespective of gender. However, the reality is far from near. Hence, while constructing a framework that is instrumental in reflecting on which routes to leap, considerations of platform service functions, network connection mechanisms, and available technologies come as functional parameters representing the current situation of Indian makerspaces. This section expounds on such a framework. Additionally, Jiancung et. al (2021) outlines four main operating mechanisms for effective innovation in makerspaces. They are *platform service mechanisms* that basically provide the infrastructure and tools, *resource aggregation* that determine the costs of resources that are needed for entrepreneurial endeavors, *network connection* that would promote knowledge-sharing and mutually shared benefits among the peers and stakeholders, and endogenous culture guarantee that essentially sustains the entrepreneurial spirit of the participants through community assistance. They set eight measurement variables over these mechanisms: the number of service functions, the autonomy of service selection, resource collection channel, heterogeneous resource integration, formal connection, informal connection, achievement sharing culture, and fault-tolerant culture. Taking from the usefulness of these dimensions, I employ these to study them in the Indian scenario. The interviews intended to map these criteria not to measure the innovation performance of the makerspaces but to their impact on the female maker's right to tinker and innovate. The importance of formal policy support and more peer-to-peer engagements are needed for these makerspaces to sustain and propel through more extended incubation periods. While platform services are relatively egalitarian and set right on the path, resource aggregation and network connections are predominantly male-led, hindering the female right to tinker. However, from the cases of feminist hackerspaces in the US, we learn that care, inclusion, and development of personal competencies were the essential immaterial outcomes of the women in CSCW (Bardzell, 2014; Fiesler et al., 2016; Lindtner, 2013). They

emerge as more fault-tolerant makers when their network connections are strong. Indian makers interviewed here for the study responded affirmatively to the importance of a community of practice. The interviews conducted reveal that informal network connections, which may positively influence the innovative performance of the makers (Lu Shi, Tianhong Jiang, 2021, p 263), often exclude women from the dialogues.

While it may not seem challenging in a digitally connected world, there are practical difficulties for women being there for other women and discussing innovation. Indian makerspaces derive income from consultancy and training services and the partnership projects they sign with governments and corporates. The source of income compromises the autonomy of service selection listed above. While mentorship attracts women on board, it is seen that membership for women is nowhere subsidized. On average, a monthly membership for primary access to tools and minimal mentorship lies around Rs. 2000 to 3000 per month. Membership plans are costlier for meeting networking needs and accessing sophisticated tools. The rates are widely uniform in all the ten makerspaces that I interviewed. While four of these spaces offered discounts for students, the unemployed, and freelancers, they invariably had no specific concession plans for women. This, in a way, is suggestive of less affordable spaces for women, thereby impeding their right to participate and innovate. At the end of the day, businesses have to run on sustainable models. The logic of capital and profits drives intelligent economies. As one male-identified makerspace owner plainly said when asked about the existence of women-centric plans in his makerspaces, he expressed that it is "*practically difficult to find a middle path between the community and commercial routes"*. This also reveals the need for continuity across verticals – starting from the tinkering labs at schools (such as the Atal Tinkering Labs), where the teenage girl essentially gets to know of the existence of such avenues, to university and library makerspaces where she gains the freedom to use artifacts and test it for herself, and then towards private makerspaces where she expands her autonomy to make, innovate with individual self-expression.

Makerspaces that are set up at places such as schools, universities, and libraries, especially when they are public-funded play an important role here. They enable aspirations to evolve and sustain at an earlier age. Her right to tinker does not culminate here. Private makerspaces

when operated in silos, as most of them do in India, without a network connecting them that encloses both formal and informal connections and interactions with incubators and the larger entrepreneurial ecosystem, are often bound to fail in fostering maker-entrepreneurs, let alone the female-identified ones. Based on the interviews, it is observed that the makerspaces that are more than five years old in the business have built up and associated themselves with co-working spaces and incubator cells. Immaterial innovations and Samuelson's case for 'freedom to optionally share innovations arising from tinkering' come at this stage – where networks are established well to provide a space for women.

From the interviews and surveys of participation that were carried out, it is found that a maker identified as female utilizes these spaces to 'make' only for an average of not more than six months. All of the eight makers under study were involved in such short-term projects. In most cases, it is to create something for personal interest or an academic trial. They find that the path towards putting forth and scaling up the product is strenuous. Two main factors, according to the respondents, come into reasoning. One, location matters. This was emphasized by everyone I interviewed. Even though most emerging makerspaces are centered around cities, a female maker accesses the ones near her university spaces or those that are not remote. No incentives or concession plans would encourage her to overlook this aspect of a safe commute. Simply put, her right to tinker comes with her right to access these places with a sense of safety. Even after creating her product, attending incubator and investor meet-ups are painstaking if these are based on short-term summits and melas only in selected cities. Secondly, the prevalent apprehensions over the state policies for innovation and entrepreneurship must be addressed. While the state sponsors infrastructure and has created tinkering labs at schools, the lack of expert trainers and facilitators makes certain spaces void. As it was noticed in the study, investments and CSR funding from the corporates towards these emerging makerspaces largely focus on investments in components, not on personnel. This substantially hinders female makers' larger aspirations of entrepreneurship and economic self-emancipation. Knowledge production and mentoring do not happen at radical strides. This is to say that these spaces have created equal access to the modes of production for

women. Still, due to the lack of investments in personnel, the co-designing processes and the technological outcomes preserve the existing masculine structures.

Conclusions

The research started with the quest to locate women in the digital and innovation economy. It meant understanding the processes and tools that enable a female maker to participate and transform her creative self. From that point, makerspaces in India are yet to create spaces that fulfil diversity at its best. Nevertheless, it allows us to devise suitable policy tools for enabling makerspaces as sites for alternate value creation. In a scenario with very dismal involvement at these spaces, the dynamics of women's participation should not have been the object of study. Still, the lessons from certain makerspaces outside India can encourage us are immense to learn and emulate. While technologically developed economies, especially in Europe and the US, have exclusive "feminist makerspaces", we find that there is no such thing even in India's best cities. Furthermore, it is found that there are no women-centric concession plans or policies at the private makerspaces. Private makerspaces, for obvious reasons, desire to run on a viable business model. Given these, the study has engaged with themes from participation to the role of justice. In sum, three trends are observable. One, the extent of female involvement and ownership is dismal (to a meager 2 to 10 percent). This extends and impacts the ways of value creation. That is, makerspaces that tend to move beyond the organizational boundaries, may fail to co-evolve, given the lesser female participation. Secondly, although these makerspaces produce low-cost and innovative technologies, feminist technologies that aid and expand women's role and capacities are not produced in substance. This again, is attributed to dismal participation of women in the first place, and the lack of feminist knowledge production in these spaces. Finally, these places promise a labour that is emancipated and unalienated. Women work on their product to express their creative freedoms. Still, a male-centric peer-to-peer engagement may hinder a female maker's possibilities of scaling up her innovation and entrepreneurial ventures.

Based on these observations, the following recommendations are made. Firstly, to deal with the concern of bringing more female participation, the disconnect across verticals has to be addressed. That is, to ensure the continuity of knowledge and artisanal skills, makerspaces should hold integrated ambitions across schools, universities, libraries, and then to private spaces. As observed in the previous section, early-stage exposure to tools may help the female maker's belongingness. Secondly, various venues of public-private partnerships can be explored at these places to subsidize the cost of entry for a female maker. Concessions and affordable entry to these spaces will encourage more women to access these spaces. Thirdly, to nurture unalienated labor value and personal agency, professional training and mentorship shall be given in directions that will enhance and build women's network connections. By these, even when these makerspaces are constantly evolving with newer tools and prototypes, the basic right to tinker and her entrepreneurial spirit shall be upheld under any circumstance.

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