

Critical Making

CRITICAL MAKING

BASELINE

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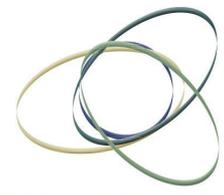
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LIST OF ACRONYMS AND ABBREVIATIONS

GIG	Global Innovation Gathering e.V., Germany
GIM	Grassroots Innovation Movement
HCI	Human-Computer Interaction
PAR	Participatory Action Research
RIMA	Reflexive-Interventionist or Multi-Agent Research
RRI	Responsible Research and Innovation
TUB	Technische Universität Berlin, Germany
VTT	Teknologian Tutkimuskeskus VTT OY, Finland
WIF	Wikifactory Europe SL, Spain
WP	Work Package
WP1	Project Management
WP2	Critical making knowledge-base
WP3	Case Action: GENDER
WP4	Case Action: YOUNG TALENTS
WP5	Case Action: OPENNESS
WP6	Evaluation, Impact, Future Implications
WP7	Dissemination, Exploitation and Communication
ZSI	Zentrum für Soziale Innovation, Austria

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EXECUTIVE SUMMARY

The term “critical making” has brought the principle of making (or, to briefly summarize, the extension of DIY culture through technology) closer to the framework of responsible research and innovation (RRI) not only in academia and design, but also in grassroots innovation movements (GIM). Such responsible innovation approaches reveal themselves in the maker culture’s commitment to openness, reflexivity, and its collaborative innovation processes. However, a framework that allows researchers to examine RRI principles in GIM has not yet been developed, and transdisciplinary scientific insights are necessary to better understand the processes of maker communities. Whether makers and maker communities follow the principles of RRI in other aspects, has also not been studied so far. These are thus the main goals of this project.

The aim of this report is to support the endeavor outlined above by situating the term critical making in relevant scientific disciplines, summarizing the state-of-the-art of critical making and understand the opportunities that lie within grounding critical making in grassroots innovation processes for the Critical Making Consortium. As the Consortium aims to work with the grassroots innovators who “make critically”, the report also aims to identify participatory methods that will allow academic and non-academic co-researchers to collaboratively explore and improve responsible research and innovation (RRI) processes within those grassroots innovation practices.

The report is divided into 3 main parts: 1. a state-of-the-art report, 2. preliminary versions of the analytical framework and 3. a methodological toolbox.

The state-of-the-art report is based on literature review and desktop research with a special focus on best practices, research gaps and opportunities. This state-of-the-art report begins with a review of relevant academic literature to situate the research of the consortium: with a focus on human-computer interaction (HCI) and science and technology studies (STS), literature on social and grassroots innovation; the critical theory of technology, various relevant innovation studies and grassroots innovation movements. It also identifies literature on critical and practices and innovations in grassroots, to establish which research this consortium builds upon. Then, the history and roots of the term critical making are collected, to gain a better understanding of its origins, various meanings, and different approaches. The state-of-the-art of critical making is to be defined here, which is a term coined in 2009 and used to describe different practices. This will help the consortium better situate its own work to build upon existing definitions, methods, and approaches. The final part of the state-of-

the-art report dives deeper into how grounding the term critical making in grassroots innovation will help better understand the criticality, reflexivity, and responsible practices of innovation within grassroots, involving the points of view of grassroots practitioners. It will also outline the consortium's working definition of critical making, to be further developed during the whole project period.

The second part of the baseline document aims to support the work of the case actions, all 3 of which engage with and reflect upon maker practices and use participatory methods. Therefore, it proposes two tools, both preliminary, rooted in theory, and translated into practice for (non-)academic co-researchers. This includes a first version of the analytical framework, which is being defined in close cooperation with WP6 to ensure its relevance. It blends the GIM analytical framework (a framework developed to understand how GIM provide a source of reflexivity in society through mainly retrospective review of their contexts, framings, spaces and strategies, and pathways) and four process dimensions of RRI (anticipation, reflexivity, inclusion, and responsiveness). A 4x4 matrix is developed, reviewed and will be co-creatively turned into an interactive tool for evaluation and self-evaluation. Finally, a first version of the methodological toolbox is presented. This includes an interactive tool for self-evaluation based on the "Sustainable Making" principles created by a group of grassroots innovators and short summaries of participation-based research approaches, outlined in engaging ways as input and inspiration for the co-design activities in WP3, 4, and 5. These are preliminary versions and are to be further developed with maker communities and in conversation with the co-researchers of the work packages. These case actions will act as testing grounds for the individual tools and will be iteratively developed together with the practitioners to ensure that they reflect their needs, practices, and are useful for them in their daily work creating, developing, and deploying responsible innovations.

In Annex 1, a peer-reviewed article by 2 consortium members is included that helps understand the logic and first steps in grounding the term critical making in grassroots practices. Annex 2 contains the GIMxRRI matrix, which is currently in a preliminary stage and will be further developed in the next months, this is thus only added here as an illustration. In Annex 3 outcomes of the case action co-design workshops and some thoughts about the potential next steps for the case actions are presented, based on input from practitioners.

1. STATE-OF-THE-ART ANALYSIS

This state-of-the-art analysis aims to research and summarize relevant literature that is needed to situate critical making, the focal term of the project, in relevant theories about society and technology, computing and innovation.

The term critical making is not new, in fact, it has been freely developing and adopted by various researchers and practitioners, and it is used in this consortium for the first time as an approach for describing RRI practices in maker-innovator communities. There is thus a need to summarize the origins and development of this term to be able to understand how it came to be that after a decade, critical making started to become grounded in grassroots innovation processes: critical makers have been repetitiously highlighting values such as inclusion, ethics, responsibility, reflexivity, or openness (Sipos and Wenzelmann, 2021). All these strongly resonate with the principles of responsible research and innovation. What complicates the research is that critical makers are not a homogenous group, but diverse “global assemblage” of grassroots innovation movements that demonstrate responsible innovation processes.

The aim of this project is to further develop the concept through the lenses of Grassroots Innovation Movements (GIM) and Responsible Research and Innovation (RRI) principles and to better understand those processes through participatory methods. First, the state-of-the-art of critical making is outlined so that a theoretical re-definition and re-conceptualization of responsible innovation in grassroots critical making can take place, which creates the basis for future research.

1.1. INTRODUCTION

Academic attention on Grassroots Innovation Movements (GIM) has been increasing in recent years, fueled by the “era of participation” (A. Smith et al. 2016). Interest in makerspaces as spaces of bottom-up innovation has been growing, together with imaginaries around the possibilities of the maker movement. Bringing about a new industrial revolution (Anderson 2012), democratizing innovation and technology by empowering the consumer (Tanenbaum et al. 2013) to make their own products through

prosumerism (Paltrinieri and Esposti 2013). Maker communities have been celebrated for potential and far-reaching impacts, be those social (Unterfrauner et al., 2020, Bosse et al. 2019), political (Maxigas 2012), or environmental (Lange, 2017, Kohtala, 2016) impacts. Whether the promises truly deliver those positive impacts is debated, critique towards makers' technosolutionism and ideological colonialism (Lindtner et al. 2016), its involvement with the U.S. military (Finley 2012), and concerns regarding "forgetting open hardware" (Benchhoff 2016) have been expressed. The self-empowerment through entrepreneurship rhetoric of the movement in the USA has also been criticized, especially the "maker industry", which has become an example for capitalism's ability to instrumentalize any movement that might undermine it (Morozov 2014). Those communities that follow the underlying principles of making are significantly less visible in the mainstream narrative (a corporatized version in which "everyone just buys the kit" (Hertz 2012)), but are very interesting in terms of scientific research on grassroots innovation.

When conducting research on the maker movement, it is important to note that we are not faced with a uniform activity that follows one central blueprint and should be reproduced anywhere in the world exactly as prescribed. Following Ong and Collier's definition (Ong and Collier 2004) it is rather a "global assemblage" (Lindtner et al. 2016) of hacker- and makerspaces, spaces of collaborative design and grassroots innovation, brought to life by offline and online communities that make use of the tools found in these spaces. Examining their diversity and situatedness (Lindtner and Lin 2017) in local socio-political realities can help extend and redefine what constitutes as making and shed light on (hyper)local societal questions. But the lack of uniformity also makes research complicated. Innovative activities of groups of people are often carried out "beneath the radar" of academia and industry (Smith et al. 2016).

Hacker- and makerspaces are localities that attract inquisitive people, early adopters, and creators of innovative artefacts. However heterogeneous, these spaces of grassroots technology innovation practices (ibid.) provide researchers with opportunities to observe processes of collaborative, collective or community-based design (Bonvoisin et al. 2018). Makers and maker communities often engage in grassroots innovation, act as litmus tests to measure the (dis)contentedness of society, and pinpoint emerging societal needs and propose change. While neoliberal, capitalistic, startup-oriented makerspaces are prevalent throughout the Western world, many communities engage in a different kind of making that is community-based, aimed at raising awareness about or even solving

local issues and thus solve problems deemed too small for mainstream innovation, and producing knowledge that might be uncomfortable for decision makers. Some of these practitioners refuse the maker label (Chachra 2015), some of them use the term critical making to describe their practice (Fonseca 2015), but there is no standardized term for these practitioners. We chose critical making because it combines critical thinking and making (Ratto and Hockema 2009), thus the underlying idea is close to RRI, and preliminary research shows that even though they don't necessarily utilize it for themselves, the term does resonate with grassroots practitioners (Sipos and Wenzelmann 2021).

1.2. GOALS AND METHODS

This report aims to summarize the state-of-the-art of the term critical making to develop the background study of the Critical Making project. It begins by creating a comprehensive overview of the current state of research on Grassroots Innovation Movements, hacker and makerspaces and their activities, the history and evolution of the term critical making, its grounding in grassroots, and cross-cuttingly highlighting various (critical) academic discourses around these topics. It also aims to identify research gaps and opportunities and further develop the proposal to steer the work of the project members.

While the state-of-the-art report mainly relies on literature review and desktop research, it also includes key learning from various community-based workshops, including a workshop at the 9th International Conference on Communities and Technologies organized and summarized in a peer reviewed article by Sipos and Wenzelmann (2021), as well as key learnings from internal workshops (on the state-of-the-art of critical making, and one on co-defining critical making for the project itself) and a 2-day co-design workshop on "Exploring Critical Making"¹ organized in the context of this project, inviting researchers and practitioners, all of which took place online, digitally, during the first 6 months of the project.

1.3. LITERATURE REVIEW

The following literature review focuses on theories relevant to situating and better understanding making and critical making. This literature review starts with a theoretical embedding. It briefly summarizes theories on technology as a black box, the critical theory of technology, relevant theories of STS (the Social Construction of Technology

¹ <https://wikifactory.com/@carolportugal/stories/interactive-workshop-exploring-critical-making>

(SCoT), Social Shaping of Technology and Actor-Network Theory (ANT)), digital humanities, and HCI (participatory design, postcolonial computing), and the few relevant enquiries where grassroots movements were explored as community-based versions of technology, science and innovation (alternative science and technology). In the second part, grassroots digital fabrication is discussed against conventional innovation theory, and placed in social innovation studies and non-market driven innovations, grassroots innovation movements and their knowledge production processes. Finally, literature on grassroots (critical) maker practices is summarized, including a brief overview of the most relevant framings of maker activities and critical making in academia.

1.3.1. Theoretical embedding: STS and HCI

The interventionist and transformative theoretic work of the Frankfurt School of Critical Theory is relevant for the project, especially as Ratto, who coined the term critical making, highlights Frankfurt School scholars such as Adorno and Benjamin. Central to their work was the idea that criticality entails not just reflection but also intervention in society (Hertz 2015, page 37). Marcuse, Adorno and Horkheimer share a conception of a 'critical theory' understood as adjacent from the dominant academic concept of 'theory' present in scientific work of that time. Rather than focusing on generalizable descriptions of current conditions, critical theory was primarily concerned with understanding and constituting 'reasonable conditions of life' (Horkheimer 1972). Critical theory is a relevant source for reflection about society, however, it was only the first generation of critical theorists that concerned themselves with technology, and that has been outmoded by historical developments, while contemporary critical theory has largely ignored it (Delanty and Harris 2021). Stiegler and Feenberg provide a more robust theory of technology. Stiegler argues for a technology that is based less on 'entropy' (or moving towards fragmentation, destabilization and disorder) than on 'negantrophy' (a form of integration that makes possible human flourishing and care (Stiegler 2017, Stiegler 2018). Feenberg, building on the work of the Frankfurt School in his Critical Theory of Technology, combines insights from philosophy of technology and constructivist technology studies. He argues that modern technologies are not neutral, they embody the values of a civilization, and thus, their negative effects are not a mere side-effect. Feenberg, similarly to the maker movement, advocates for broader democratic participation are needed in technological choices to understand technology's democratic potentialities (Feenberg 2005). Trade-offs between efficiency (typical for industry) and participation or sustainability (often seen within maker communities) is another interesting research question.

As RRI's main goal is bring together various societal actors to research and innovate together so that the innovations better reflect society, theories that help understand the interconnectedness of technology and society are also relevant. One of the most prominent academic discipline is STS (science and technology studies, or science, technology, and society studies), as it studies the broader implications of technology, science and society. Like critical theory, STS is anti-technocratic and an expression of radical thought, though its inspiration derives from postmodern theory rather than from modern thought. Relevant theories of STS such as the Social Shaping of Technology, the Actor-Network Theory or the Social Construction of Technology can be utilized (Bertling and Leggewie 2016) to better understand the dynamics of maker culture, maker communities and their innovation processes.

The Social Construction of Technology (SCoT) challenged the technical aspect of technological determinism – arguing that technology does not determine human action, but human action shapes technology (Bijker 2009, Bijker and Pinch 1987). Makers engage in socially constructing and shaping technology through prototyping and coding daily, and a better understanding the communities' points of view during and represented by their practices in identifying and developing solutions for societal problems can be created with the help of SCoT.

As Social Shaping of Technology (Williams and Edge 1996, Bammé 2009) was developed as an answer to the techno-economically rational and linear conceptions of technology and its negative consequences, it gives users a central role in (further) developing technologies, such as users as agents of technological change and prosumers (Oudshoorn and Pinch 2008 p. 554), both of which resonate with the co-productive practices of maker communities.

The Actor-Network Theory (ANT) highlights the symmetry between human and nonhuman actants (Latour 2006), which allows for researchers to show how the roles the developed objects play beyond their purely technological role, sometimes symbolically, reflecting the societal purpose they play, which is especially important in critical making. While in mainstream innovation (and often in mainstream maker culture), objects are merely consumed, in social innovation, responsible innovation and grassroots-based critical making products are created based on values, through interactions and negotiations, reflexive practices, in co-creative processes between human and non-human actants, as opposed to pathways of objects in the consumerist society.

Motivations of the maker movement around open source technology can be interpreted through Winner's work. He wrote about power relations, social constructivism and the philosophy of technology, and most importantly, the opening of the famous "black box" that technology has become (Winner 1993). Similar critique has also been expressed by the Critical Engineering Working Group (Oliver, Savicic, and Vasiliev 2011) and Garnet Hertz, as he was extending the term critical making to mainstream maker culture (Hertz, Levin, and McGuirk 2014). Both advocate against the practice of "black boxing" or closing technologies and taking away the agency of people to turn them into mere consumers. This is one of the issues maker culture aims to resolve through technological literacy, repairability and prosumerism.

Latour has asked himself why has "critique run out of steam" (Latour 2004). He blames the absence of principles: critique has battered through all claims to a ground, eroding any sense of a solid foundation, and with it, a compelling argument. The result is that there isn't even a sure ground for criticism, for example to go against conspiracy theories. Building on this, Dada brings the example of a critical maker, who, based on the expertise they gain during their practice, through research and making can become a witness against the experts, able to give evidence against their predicted events before they happen (Dada 2019).

In addition to STS, Ratto also mentions Digital Humanities scholars who highlight concerns about digitality and information more generally, including the emancipatory and constraining aspects of 'technoscience', such as Haraway, Star, Bowker or Latour, as a source of inspiration for academic critical maker projects (Ratto and Hertz 2019).

In recent years, hacker and maker culture and grassroots innovation has been gaining attention in the Human-Computer Interaction (HCI) community, but participatory design originated decades ago, with workers successfully calling for participation in the design of the systems that affect them (Ehn 1989). Based on the same fundamental values of democratization and empowerment, and with technologies becoming both more ubiquitous and more accessible to more people, researchers within and beyond the field of HCI have developed frameworks and methodologies to support technology design for and with the affected communities (Marquardt et al. 2017, Rohde et al. 2017, R. C. Smith, et al. 2017, Smyth et al. 2018, Taylor et al. 2017). Hackerspaces and the practices of DIY makers have been explored as "Emerging Sites of HCI Innovation" (Lindtner et al. 2014). Making is also explored in relation to keywords such as post-colonial computing (Kaiying et al. 2019), and a tactical survey was conducted related to ICT4D drawing on critical

theories of colonial and postcolonial technoscience (Philip 2010). Utopianism has been used for a speculative imagination and exploration of alternative futures of making to reconstitute the utopian vision of making (Lindtner et al. 2016). These explore making in its societal setting and encourage critical reflection regarding the vast differences between narratives of mainstream and grassroots innovation processes and broaden the term to encompass Western and non-Western making.

1.3.2. Relevant Innovation Theories

For this project it is very important to note that so far, relatively few studies have linked social movement literatures to studies of science, technology, and innovation (Smith et al. 2016 page 18.). As the maker movement is a social movement that is heavily involved in community-based science, technology development and innovation processes, more interdisciplinary research is needed to further develop our understanding these interconnections. However, as explained here, their innovations remain almost invisible because of the scale and impact, thus, it is important to research them differently, moving away from conventional innovation studies. Alternative technology, social movement and social innovation studies, the creation of new social and power relations, and knowledge produced by communities of practice are keywords to a better understanding towards grassroots critical makers.

Makers are at the forefront of community-based innovation and technology development, while addressing issues that remain under the radar of industry, government, and academia, because their relevance seems (hyper-)local, or the solutions require personalization that is difficult to do on a large scale and is thus deemed unprofitable. Examples of successful attempts to make similar connections between social movements and mainstream R&D include studying the role of social movements and collective action in the construction of alternative science (Frickel 2004, Frickel et al. 2010, Moore 2006). In *Alternative Pathways in Science and Industry*, Hess wrote about issues neglected by conventional scientific institutions and addressed by activists and the role of movements in developing alternative forms of technological change (Hess 2009), and the development of alternative technologies (Smith 2005) has been researched.

As Smith et al point out, making, or grassroots digital fabrication “sits awkwardly with conventional innovation theory” (Smith et al. 2013). There is indeed growing interest amongst researchers to explore different versions of grassroots innovation, user-centered innovation, open innovation, social innovation, frugal innovation, and community innovation - proliferating adjectives reflect the fact that agents, arenas,

agendas, and processes of innovation are opening up in society (Elliott and Turner 2012). However, to gain a more complete understanding of such alternative innovation processes, we need to further develop theories centered on innovations taking place in the broader field of society, or more democratic innovation processes, like grassroots innovations. Innovation is still seen as something coming from academia, government, driven by industry: major players with large budgets and seemingly infinite resources. Opponents of such large scale innovations advocate for locally developed solutions for local problems instead of one-size-fits-all solutions deployed “from above” (Schumacher 1973, Campbell 2018). For the last decade, the maker movement (often building on or working with other grassroots movements) has been playing an integral part in developing grassroots capabilities for innovation and has been seeking to propagate them through society (A. Smith et al. 2013).

Social innovation studies provide suitable frameworks for grassroots innovation processes, as these include theories not only on community-driven, bottom-up approaches, but also a focus on values and needs/issues of communities, social change, and non-market driven innovations. The strong tradition, a radical approach to social innovation defines it as “the political transformation of society through creating new social and power relations” (Moulaert et al. 2007, Moulaert et al. 2010, MacCallum et al. 2009). Non-market driven innovations focus on the satisfaction of needs, reconfigured social relations, empowerment, or political mobilization, and innovative processes are at the forefront: “by focusing on the innovation, rather than on just the person or the organization, we gain a clearer understanding of the mechanisms that result in positive social change” (Phills et al. 2008).

Smith and his colleagues place hackers and makers among grassroots innovation movements (see chapter 6 “Hackerspaces, fablabs and makerspaces” in (Smith et al. 2016). Thus, theories on GIM apply, including being characterized by knowledge production (Eyerman and Jamison 1991 in Smith et al. 2016), on knowledge neglected by conventional innovation institutions, through the means of non-proprietary forms of innovation. Social movements are social actors that learn by doing, and especially in the case of makers, they learn by doing together, meaning that these are “communities of practice” (Lave and Wenger 1991), and they learn together often through reflection and debate.

The knowledge produced ‘might be inconvenient to and resisted from those above’ (Cox and Flesher Fominaya, 2009 p.1. in Smith et al. 2016), while movements’ critique for

example of existing inequalities enhances the reflexivity of society (Buechler 2000 in Smith et al. 2016). They are thus political actors, in the sense that they are initiators of alternative pathways of socio-technical development that raise questions about technological needs in societies, appropriate directions of technological change, and who is enabled to design, own, access a technology. They challenge specific directions and forms of knowledge production, technological change and development (Smith et al. 2016). Knowledge production (Jamison 2001) and co-creative knowledge sharing is a relevant activity of maker communities, including sharing the produced knowledge and open source blueprints online. Escobar, a decolonial scholar has highlighted different kinds of knowledge production approaches by social movements (Escobar 2004), and (Leach et al. 2010) have described the politics of knowledge involved in social movements.

1.3.3. Literature on Grassroots (Critical) Making Practices

Maker communities have developed their own framings, and some of these have been getting increasing attention in academic research. Distributed manufacturing and sustainability (Kohtala 2017a, Berglund and Kohtala 2018, Klemichen et al. 2018), making as post-capitalist practice (Baier et al. 2016) and attempts to diversify the economy (Smith 2019), education (Unterfrauner et al. 2019, Monfredini and Frosch 2019) or citizen and open science (Fisher and Gould 2012, Chan 2019) in maker communities have been discussed in academic literature. These are some of the more mainstream framings of social and environmental causes the “global assemblage” of makers can identify with, while educational programs are not only part of their values (knowledge sharing) but can also contribute to their financial sustainability. Social scientific analysis of makerspaces and grassroots digital fabrication/innovation movements has thus begun to emerge, but a focus on criticality, reflexivity, or responsible innovation – the main focus of this project - has been rare.

As (Richterich and Wenz 2017) summarize, inherently critical approaches have been discussed (Ratto 2011, Hertz 2012, Alper 2013, Kohtala 2017), as answers to optimistic promises and overstated manifestos (see e. g. Morozov 's article (2014) in which he comments on Hatch (2013) and Anderson (2012). Literature on critical making in grassroots with analyses that focus on the activist nature of these practices can also be found under the terms “DIY maker-activists” (Kohtala and Ede 2019), “maktivism” and “tinqiry” (Ratto and Boler 2014b), page 3). The latter is by date the most important collection of academic essays on critical making in bottom-up, grassroots innovation.

Based on a 2010 conference with the same title², *DIY Citizenship: Critical Making and Social Media* (Ratto and Boler 2014) was the first book to explore critical making in the everyday lives of people, or these emergent communities of critical makers who engage in political discourse as “DIY citizens” (ibid. page 5).

1.4. SOCIAL AND RESPONSIBLE INNOVATION IN MAKING

While DIY itself is not new, as the movement became mainstream, this has brought with itself a „Silicon Valley ethos“. This became visible e.g. when the MakerBot, „the darling of the Open Source Hardware movement“ became closed-sourced (Benchoff 2016). Amongst others, Garnet Hertz has been an outspoken opponent of maker culture becoming a market-driven segment of DIY, while the original countercultural aspects of the movement seem to have vanished. He has been criticizing this US-centric and startup-culture-based approach to making as apolitical, exclusive, and wasteful: when practitioners take part in predefined activities and only build seemingly life enhancing artefacts out of kits, there is little space left for creativity, speculative processes or reflection (Hertz 2012)³.

As Lindtner et al. summarize, making is used as an utopian term that envisions the democratization of technology production (Anderson 2012) and the narrative around the movement can be defined as technosolutionism, which is the view that technology can unilaterally solve difficult social problems: furthering sustainability, social justice for women, economic development for the Global South, empowerment for all (Lindtner et al. 2016). A reconstitution of this utopian vision and an observation of its democratizing potentials in technical and socio-political perspectives is proposed through reflexive-interventionist approaches, calling for more critical reflection and engagement with members of the movement (ibid.).

Smith has also pointed out the makers’ dilemma of asymmetric power relations: sources of funding for maker- and hackerspaces versus their community values: „Hacker visions and values for autonomous social innovation and critical involvement in open technology is co-opted by an agenda to educate, train and entertain people, and where the fear is

² Organized by Prof. Boler and Prof. Ratto between 12-14 November 2010 . The dedicated website <http://diycitizenship.com> was not working during the writing of this report, but further information can be found at <http://sites.utoronto.ca/csus/Conferences.html>

³ This is a rather political/provocative statement aimed at Make Media’s capitalist approach to monetarize making. As of the reviewers pointed out, even though some ideologies might “instrumentalize” making, it still leads to acquiring digital competencies, and existing building blocks still foster creativity, the picture is thus more nuanced.

that it reinforces compliance with conventional innovation agendas. Responses to this criticism point to the mainstreaming of makerspaces but gloss over the asymmetric power relations between partners. In terms of innovation democracy, the critical question becomes the conditions under which makerspace participants can really challenge, and even reshape, the agendas of sponsors and partners." (Smith 2017)

Makerspaces can play important societal roles: by offering third places for communities⁴, supporting wellbeing (Taylor et al. 2016) and supporting civic engagement through notions of activism and critical thinking, unlocking grassroots capabilities (Bar-El and Zuckerman 2016). They also create innovative artefacts by using different or inclusive design methods, they support the creation of socially relevant prototypes, some of which can be innovative solutions, e.g. frugal innovation and appropriate technologies, to societal problems (Beltagui et al. 2019, Smith 2017). Particularly in the Global South, some makerspaces already realize their role as societal and political actors, as can be seen e.g. in the citizen-driven projects of LabCOCO at the Umbigada Cultural Center in Brazil, the Hack-a-Toy workshops offered by Engineering Good in Singapore, the ASKOtec mobile makerspace employed inter alia in refugee camps in Uganda, or Lifepatch, a grassroots initiative exploring science and technology, experimenting DIY biology in Indonesia.

Social innovation in the maker movement needs to be viewed under a critical lens. Thousands of maker spaces in libraries, universities, publicly accessible and privately-owned spaces bring together hundreds of thousands of makers worldwide today. This means that several society members are engaging in this activity, but do the spaces engage in changing society? It is inherent that at such adaptation, the societal impact could be far reaching. There are a lot of maker spaces already aiming to create communities for their members, contribute to the improvement of the lives of people, or help them understand that technology does not need to be an inaccessible black box. Makerspaces don't necessarily self-identify as spaces of social innovation, but some work on solving societal issues through knowledge production, innovation, and community building. It is yet to be researched, what the types of societal impacts and level of RRI in maker communities might be. Currently, most solutions are not yet sustainable, long-lasting, or impactful and socially innovative artefacts represent the minority of prototypes made in makerspaces. But we do know that there is resistance towards the mainstream

⁴ Third places are welcoming spaces outside of our work and home that have been created for social experiences for like-minded people, relevant for civil society/democracy (Oldenburg 1989)

“maker industry” in maker communities, and the critical and sustainable making frameworks offer a chance to “combine practices of making with critical (and sustainable) thinking respectively, to explore topics utilizing technologies and materials and thereby creating tangible artefacts which have a societal impact (Sipos and Wenzelmann 2019).

It is also important to note that in addition to the mainstream rhetoric of the entrepreneur maker, and due to their educational backgrounds, makers in Western countries often use standard engineering practices to solve issues, and this might limit their societal impact. Reproducing industry practices has been criticized and has proven to be insufficient when it comes to societal change. If innovating for society is the goal, it is required for practitioners to rethink how they innovate and engage in multidisciplinary processes that include critical thinking and reflexive processes and co-creation with others. Critical making has been developed to bring together critical thinking and making – but since the beginning, it has been embedded in academic, scholarly practice and discourse, and only reached grassroots in few instances.

It was during the COVID-19 pandemic that we witnessed very clear responsible innovation capacities in makerspaces, where grassroots communities were rapidly prototyping, testing, documenting and reproducing new products that were needed (Kieslinger et al. 2021). The potential of social and responsible innovation in the maker movement is interesting for research - it has become timely to formulate approaches to ensure a better understanding of RRI in making. The pandemic has shown the risks and limits of relying solely on centralized large corporations and governments, and therefore has set off an unprecedented interest in local, distributed, and openly accessible design and manufacturing to solve the massive unmet needs that have surfaced during the crisis. Such a shift, however, needs a critical view on its social responsibility and ethics.

1.5. DEFINING MAKING AND DEFINING CRITICAL

To make critically is a relatively new concept in academia, which so far has been used mostly in scholarly practice, art and design studios and dedicated research projects conducted by academia (Ratto and Hockema 2009, Hertz 2012, Cramer et al. 2018). Locating such practices is also difficult because terms used for self-identification in grassroots do not always overlap with mainstream terms, and as noted earlier, it is important to note that some makers refuse the maker label to describe themselves and their activities (Chachra 2015). Some feel it is too exclusive and represents a Western narrative and practices of innovation, and to describe his practice, instead of making, Felipe Fonseca, a free/open advocate and researcher uses *critical making* (Fonseca 2015).

Others use local slang words, such as the Brazilian *gambiarra* (ibid.), the Indonesian *ngoprek* for tinkering (Siagian 2016), while the Indian term *jugaad* can be translated as hack or resourcefulness, and more and more attention is directed at *shanzhai* copyleft production practices in China (Braybrooke and Jordan, 2017, Lindtner and Lin, 2017).

It is important to clarify: what is supposed to constitute as “making” and why was the adjective “critical” added to create a new term?

1.5.1. Defining Making

What constitutes as making is situated and diverse (Braybrooke and Jordan 2017, Lindtner et al. 2016). It has different definitions, most of these include the digital, technology-based extension of DIY culture, i.e. metalworking, woodworking, traditional arts and crafts, DIY biology and naturalism - and electronics, robotics, 3D printing, CNC tools. The communities value openness (e.g. the sharing of blueprints of open source hardware online), sharing, DIY and DIWO (do-it-with-others). The practice often intersects with hacker culture and there are many cross-over activities: many hackerspaces are makerspaces too⁵.

Making as a practice of Do-It-With-Others (DIWO) or Do-It-Together (DIT) instead of Do-It-Yourself (DIY) has become very popular around the world in recent years (Lou and Peek 2016). The diversity of makerspaces reflects the popularity of making as well as the diverse interpretations of the term: It is used to refer to a wide range of places, from the safe space of an activist community that utilizes practices of hacking and making, to a shared workshop where one pays for the use of machines.

⁵ See www.noisebridge.net or <https://x-hain.de/en/> “hack+ makespace”. For deliberations on the differentiations and similarities between these two terms, see (Richterich and Wenz 2017)

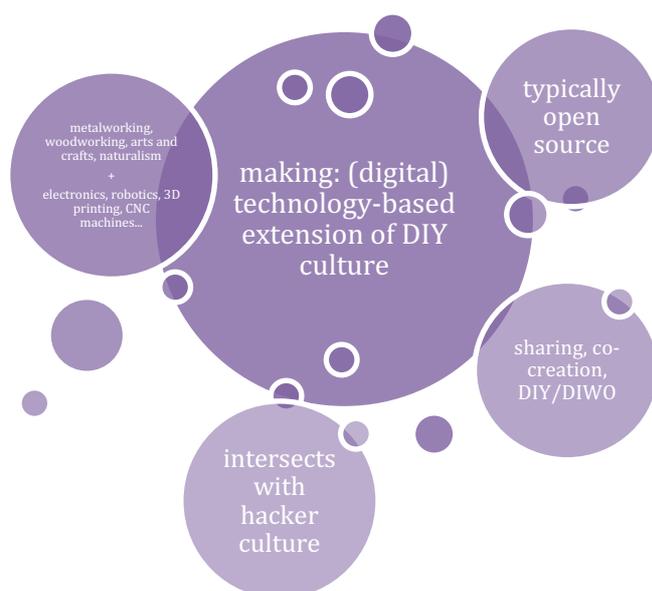


Figure 1 Dimensions of Making

The term 'maker' took on a specific usage in 2005 when Dale Dougherty founded Make magazine, which he used as a term to rebrand and sanitize the term 'hacker' to be more acceptable to the public, schools, and potential sponsors. The concept of maker started out by highlighting ordinary people making in their garages and backyards, but eventually also enveloped work in the experimental media arts, open source hardware, and hackerspace culture (Bogers 2019). Make magazine and Maker Faires have been crucial in the “maker movement” reaching millions of people worldwide, as people learned about and found sources of inspiration for DIY projects. Additionally, under the same brand, Maker Faire events allow makers to showcase their creations and learn about new tools and gadgets. Maker Faires have been organised in around 100 countries and have attracted millions of visitors (Dougherty 2012; Burke 2015).

The revival of DIY through digital tools was given great stimulus by a course at the Massachusetts Institute of Technology, which teaches students “How to Make Almost Anything” (Gershenfeld 2012). The course inspired what eventually evolved as the international Fab Lab (fabrication laboratory) Network, which provided a blueprint of low-cost fabrication laboratories (today approximately 1750 in 100 countries) accompanied by a set of values that emphasized the Fab Lab as a laboratory allowing individuals to share space and tools. In 2014, a Maker Faire was hosted by the White House (Fried and Wetstone 2014).

Basic tools, in addition to those not available in every home, such as 3D printers and laser cutters, are commonly offered in Fab Labs as well as in many other types of workshops

worldwide, such as makerspaces, hackerspaces or repair cafés. Education provided to all age groups from young children to grown adults on how to use tools was also necessary, and a version of the original course under the name Fab Academy is offered to provide this education (Martin 2015, Peppler et al. 2016, Blikstein 2017). Many other spaces also offer workshops and training tailored to the needs of their communities.

What the discourse described above rarely mentions is that people have been engaging in DIY activities for a long time and in very diverse ways, and how historical developments also contributed to the range of open workshops we are seeing today. Indeed, Stewart Brand's "Whole Earth Catalog", published between 1968-1998, is associated with the foundations of the maker movement. In Germany, the number of non-profit open workshops is estimated to be around 1000, many of which have existed for decades and can be found in smaller cities and rural areas. Aside from Fab Labs, there is a compelling diversity in the global and the German open workshop landscape, including not only hackerspaces and makerspaces, but also DIY/Do It With Others (DIWO) spaces, biologist and feminist spaces, repair cafés, mobile makerspaces, FabLabs (Sipos and Franzl 2020) and many more.

1.5.2. The "Critical" in Critical Making

The term making is thus useful to describe types of grassroots community innovation, however, the mainstream narrative of making does not really include those communities who engage in the democratization of innovation, technology literacy, and community building, but also offer spaces for criticality regarding socio-technical questions, or outlets for activist creativity (which include adversarial, tactical, political approaches) – these critical activities are reduced to a singular interest in technology. Other matters of concern are the lack of reflection, economic impact of the practice, and also diversity: the so-called "maker movement" often is presented as open to everybody and thereby democratizing technology design (Tanenbaum et al. 2013), while in fact more often than not efforts are required to include makers who are not able-bodied, cis-gender, middle-class white men between the ages of 15 and 50 (Ames et al. 2014, Jelen and Siek 2018, Meissner 2018).

Critical making raises socio-technical questions, and it can help engineers engage with complex theories, but it can also highlight societal issues through critical artefacts (for more details, see in the dedicated section below). Making, a "hard skill" is combined with critical, conceptual thinking, both together and in exchange with others. Reflexivity and

intervention are combined. How was criticality added to material practice? This is traced back below.

While critical design and critical engineering are terms that were developed in the 90's, Ratto was inspired to develop critical making by his teacher, Phil Agre's paper on Critical Technical Practice (Agre 1997). In this paper, Agre outlines his own struggles to bridge his disciplinary mindset, not having had any critical tools to defamiliarize himself with dominant ideas or to imagine alternatives, and to stop thinking the way AI-developers think and start thinking like social scientists. Critical Technical Practice is a critical theory-based approach towards technological design, where critical and cultural theories are brought to bear in the work of designers and engineers. His goal was to increase awareness and critical reflection on the hidden assumptions, ideologies and values underlying technology design, and to build reflection into the technology development process.

Agre's concepts of Critical Technical Practice were extended to HCI as "reflective design" (Dourish and Finlay 2004) and to innovative scholarship as "critical making" (Ratto and Hockema 2009). This is the "direct link" that Ratto highlights as the source of his term, however, Stoyanova traces criticality back to tactical media (Garcia and Lovink 1997), critical design (Dunne and Raby 2005), and finds its roots in homo faber (Stoyanova 2017). Galloway also highlights Kant and his anti-dogmatic interest in self-knowledge, the self-reflective quality of knowledge, the ability to validate knowledge without appeal to external scaffolding; and Marx with a slightly different sense of critique: also anti-dogmatic, self-reflective, modern, but a rather mundane, terrestrial, and non-transcendental position (Hertz 2015 pp 76-77).

Ratto's goal was to explore actual making practices and to try and come up with ways to link deep reflection and critical theory within technical activities: "I was talking about this from a very academic perspective because when I was first talking and thinking about this, my goal was to create innovative scholarly practice. I wasn't thinking about critical making as a more general form of social engagement" (Hertz 2015 page 37).

Hertz collected critical responses to the maker movement, in which he, in addition to the mainstream maker industry, found criticality in an "interplay between critical theory and hands-on practice, contemporary art, the process of developing new technologies, open

source hardware, tactical media and politics, interdisciplinarity and academic institutions, critical and speculative design, mass-produced consumer culture, and hackers and hackerspaces” (Hertz 2015 page 5).

As Dunne and Raby write in *Speculative Everything*: critical design uses speculative design proposals to challenge narrow assumptions, preconceptions, and givens about the role products play in everyday life (Dunne and Raby 2013). They speculate about questions that grassroots practice engages in: when governments and industry are incapable of dealing with a particular situation, a group of people take their fate into their own hands and start using their knowledge to build DIY devices: the contrast between bottom-up and top-down responses to a societal problem and the potential role that could be played by grassroots in solving this is highlighted through design. Their aim is to make consumers more aware of the values, ideologies, and behavioral norms inscribed in the designs that are used in their everyday lives (Bardzell and Bardzell 2013). It is through adversarial design that DiSalvo raises the questions: How can we collectively make speculative representations and prototypes of possible futures - what should come after imaginations of possible futures? (DiSalvo et al. 2010, DiSalvo 2012).

Critical engineering can be located in academia, mainly in the education of engineering students (Claris and Riley 2012), and there is a non-academic direction that raises awareness around critical socio-technical questions, see “The Critical Engineering Manifesto” by the Critical Engineering Working Group⁶ (Oliver et al. 2011).

1.5.3. Tracing Critical Making

Ratto and Hockema coined the term to describe a new, innovative type of scholarly practice:

"Critical Making is an elision of two typically disconnected modes of engagement in the world: critical thinking,' often considered as abstract, explicit, linguistically based, internal and cognitively individualistic; and 'making,' typically understood as material, tacit, embodied, external and community-oriented" (Ratto and Hockema 2009)

The term critical making was developed as an approach to innovative scholarly practice, to address and discuss “wicked problems” (Rittel and Webber 1973) in (Ratto 2011 p. 253) by using making to experiment and develop a collective frame that highlights and

⁶ <https://criticalengineering.org/en>

resolves disciplinary and epistemic differences (ibid.)⁷ It is thus an approach that is particularly relevant for the project as it informs responsible innovation and reflexive practices in making.

Subsequently, the term critical making was also adapted to help look beyond the idealized picture of the maker and to "reintroduce a sense of criticality back into post-2010 maker culture to un-sanitize, un-smooth and repoliticize it" (Hertz 2015), thus show a different face of making that dares to express critique, in the form of art, activism, or social innovation. It was also furthered to describe activities of DIY citizenship (Ratto and Boler 2014). The term has thus evolved since it was coined, and while it is not a contested concept, defining what qualifies as critical making and what does not is left relatively open. In a recent interview with Hertz, he said: "Critical making is a great term, but it's not like it needs to be an exclusive club with a VIP list - people can come and go, bend things, and mess around."⁸

Although most research seems to focus on scholarly or artistic and design activities, current definitions of the phrase are not restricted to such practices. Ratto and Boler have used critical making to discuss grassroots approaches, under the terms "maktivism" and "DIY citizenship" (Ratto and Boler 2014) and thus the consortium members also use it as a somewhat flexible and open umbrella term for the critical, socially innovative, activist, etc. activities of grassroots innovation movements using maker practices. Fig.2. below shows the evolvement of the concept of critical making.

⁷ Critical making can have various objectives: in the USA and Canada, for example, it mainly focuses on critically exploring the social issues inherent in technical systems, to acquaint students with some of the possibilities and problems of new physical and ubiquitous information technologies, and to help them develop basic skills in designing, making, and evaluating information systems that use these new technologies. The Critical Making course at the Technical University of Berlin is dedicated to gender issues and aimed at developing the critical thinking skills of students who will be leading future R&D projects to engage deeply with the problems they will be solving.

⁸ Dr. Garnet Hertz, Canada Research Chair in Design and Media Arts and is Associate Professor in the Faculty of Design and Dynamic Media at Emily Carr University, on 16th March 2021

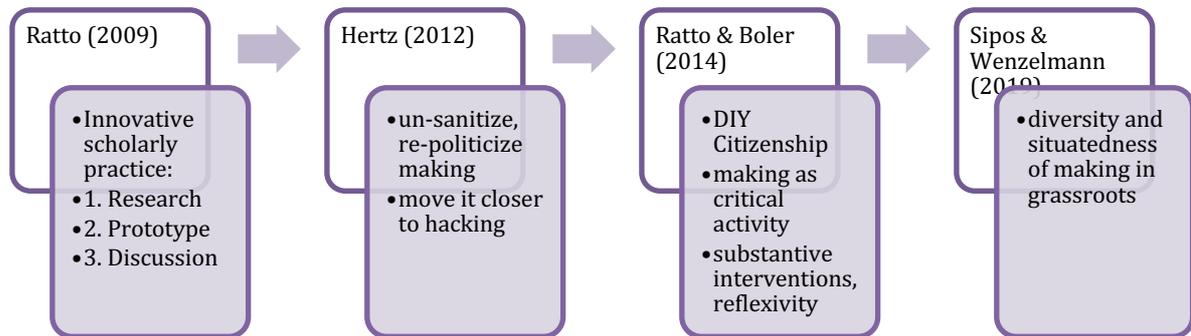


Figure 2 A timeline of critical making

However, this does not necessarily mean that broader groups of grassroots practitioners identify with the term, or that they know of it. For the purposes of this project, it is thus important to develop a working definition of what critical making in grassroots could be. In order to do we need to hear from the practitioners themselves and then ground the term in their practice.

1.6. CRITICAL MAKING IN GRASSROOTS

The potential inherent in maker communities which comes from the cumulative and shared knowledge of its members, and the technical possibilities that the democratization of innovation and access to technology through rapid prototyping offers, especially when combined with critical thinking and reflexivity is yet to be researched. What “qualifies” as critical making is not restricted to academia or artist and designers. Ratto shares his thoughts about the development of the term:

“I now see a lot more connections with (...) tactical media and other forms of material intervention. I now see critical making as a more general practice than just something academics do. Critical making as a larger category allows us to connect up a variety of practices and see them in some sense as similar, like design practice, art practice, tactical media practice, academic practice, or engineering practice. Critical making can become a kind of a common hub that a whole set of material interventions can circulate through.” (Hertz 2015 page 37)

While, as described above, most research seems to focus on scholarly or artistic and design activities, inspired by the DIY citizenship of (Ratto and Boler 2014), two (now) consortium members designed a workshop (Sipos and Wenzelmann 2019) to see if the

term resonated with grassroots practitioners, and ground critical making in bottom-up practices, which was summarized in a paper (Sipos and Wenzelmann 2021).

Although the complete paper is included below in Annex 1, it is important to briefly summarize key points here. The paper describes a workshop titled Critical Making with and for Communities was held at the 9th International Conference on Communities and Technologies (C&T)⁹ with the goal of unmasking the utopian vision of making that is resting on technosolutionism and ideological colonialism and look beyond the maker hype and its promises. It also aimed to understand whether critical making was a term that could describe the activities, processes and aims of grassroots innovation communities focusing on collaborative technology development in the Global South, if the extension of the term critical making to describe grassroots innovations was sensible, and how this term resonated with the participants. Three questions were discussed: Does making democratize access to and practices of innovation? What is critical making for you? And a circular question: Aren't all makers critical makers? Why should they be critical at all?

While many of the participants confirmed that they did think there was an inherent criticality in DIY and making, they also expressed that making was still a privilege¹⁰. Critical making for them was directly related to frugal innovation, non-Western viewpoints, and local contexts, and brings with itself a culture of community-based design approaches, discourse, reflection, and responsibility. They also shared emerging topics of grassroots critical making, like as the importance of intersectional makerspaces and the need for guidelines of how to build technology for diversity and inclusion, making as an enhancer of educational curricula and an opportunity for skills development, alongside with technology literacy for all to democratize access and practice or the importance of sharing, open-source innovation, and difficulties commons-based organizations face in achieving financial sustainability.

With regards to whether critical making is a term that grassroots innovators use for themselves, the authors state:

⁹ <https://2019.comtech.community>

¹⁰ Interestingly, one of the reviewers mentioned a similar point and shaped it into an interesting research question: while the distinction between mindless consumers and reflective buyers (or even “prosumers”) is not always obvious, making is prototyping in a setting where time and money is restricted. Is “being critical” then a merely rational decision or is it a luxury afforded by the conditions of the maker?

“ The term critical making still cannot serve as an overall description of the activities, processes and aims of grassroots innovation communities

focusing on collaborative technology development in the Global South, however, it proved to be useful in discussions between these members of the global assemblage of makers. While being aware of the shortcomings of any one term to summarize all different practices, critical making provided a framework both open and narrow enough to identify, discuss, share and better understand the different hyper-local, scattered processes which reflect the plurality and reflexivity of the global assemblage itself.” (Sipos and Wenzelmann 2021)



1.6.1. Workshop Outcomes: Locating Concepts in Grassroots

The consortium organized a co-creative workshop on 25-26 March 2021¹¹, which invited researchers engaging in participatory research with communities to share their

approaches and grassroots practitioners to present their insights related to the three case actions of the project¹². This allowed the consortium members to collect information and thus better understand the terminology used by grassroots, to create a more shared language for our work.

Collected on shared boards, these include various attributives, such as social, responsible, or frugal innovation, making, hacking, participatory design, speculative design, and co-creation. Ethical hardware and low-tech ambitions were mentioned, the complexity of nature and society vs technology and overcomplication (colonat and cosmogony). Key learnings included not using the word citizen (e.g. in citizen science) as not every person is inherently a citizen where they live, and using people’s own terminologies instead of assigning them. The participants highlighted the importance of transparency:

Figure 3 Screenshot of the shared management of expectations and frame of board from the co-design workshop

¹¹ <https://wikifactory.com/@carolportugal/stories/interactive-workshop-exploring-critical-making>

¹² The latter is described in detail in Annex 3, here the focus is on conceptualizing the term critical making.

interpretations. They advised to create safe spaces and use inclusive language (e.g. “makeuses” instead of makers; women* instead of women for trans inclusiveness), DIWO or “do it with others” instead of DIY. Thus, the importance of language used for thought processes, and concepts, but also for communication and inclusion (gender and citizenship status) and creating safe spaces for experimentation and sharing for everyone has been highlighted as relevant.

1.6.2. The Consortium’s Working Definition

One of the goals of the first 6 months and the multiple workshops organized during this time has been to develop a working definition of critical making for the consortium: discussions around what critical making is, and what critical making is not for our work have been taking place. A special workshop which was organized for the consortium members asked them to prepare the practitioners’ definitions of critical making that resonated the most with them. Then, they had to share a concrete project they defined as a critical making project and were asked to explain why they decided to share this project. Then the challenging question of “what project does not qualify as critical making” was discussed, which sparked conversations about levels of openness, the amount of digital technology a project should contain, and the definition and level of criticality in maker projects.

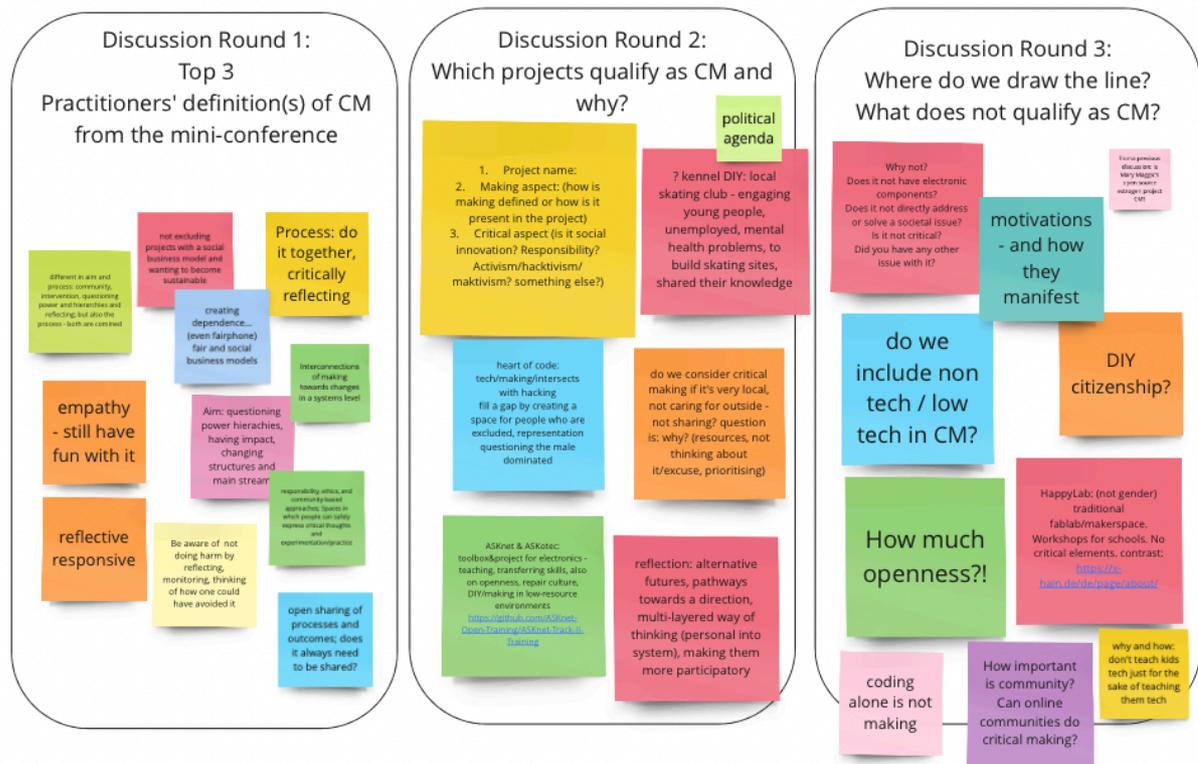


Figure 4 Developing the Project's Definition of Critical Making

In addition to the structured discussion above, the Consortium members have also raised further points as they attempted to untangle definitions, which have led to further conclusions. These include notes for the researchers, co-researchers and makers: what exactly is the impact we require? Ratto and Boler mention “substantive” impact, however, that might clash with how impact is measured in a hyper-local project, and might lead to its exclusion, however interesting it might be in terms of responsibility, sustainability, or criticality. The definition of “making” was also revisited: if knitting is used in a research project as a tool for reflection (see Strohmeyer’s research below), which qualifies as DIY, but it does not use digital technologies, should it be excluded? How much openness can the Consortium call for, should the open source license be required, do maker communities have to actively distribute their blueprints to make these truly open and accessible, what is openness in countries where IP rights are so different from the Western setting? And finally, non-commercial licenses might hold development or social good projects back from becoming sustainable – do those cause harm then while being “open”? The consortium also asked for systems thinking: this would include wider views towards potential futures, the inclusion of stakeholders, and integrating different views for learning (more about this in the methodological toolbox below).

Based on these intense reflections, the consortium came up with a first definition of critical making:

The starting statement when defining Critical Making is that it has two aspects: the making, and the critical. The “maker” part, or maker culture is defined here as a contemporary subculture representing a technology-based extension of DIY culture that intersects with hacker culture (which is less concerned with physical objects as it focuses on software) and celebrates the creation of new devices as well as tinkering with existing ones. The “critical” part integrates several important aspects:

- locally situated, community- and network-based (local and connected)
- responsible, ethically correct and addressing societal needs (social)
- based on critical thoughts and reflections on power structures (critical)
- having an impact and changing structures (impactful)
- what is made is made because it gives the makers joy and means a lot to them (joyful/meaningful).

This list of attributes has been discussed in the consortium, two in particular: the question of impact, and the question of joy.

The type of impact is still being debated, as Ratto and Boler highlight that the critical maker projects they included in the DIY Citizenship book have “substantial impact”; while Hertz proposes that in his course, students use qualitative data collection (surveys, interviews, observations, or usability tests) to understand the impact of the project, especially in measuring how it challenges and disrupts biases. Especially in the case of grassroots, which focus on solving small, local, not profitable issues, the question of traditional impact measurement is complicated, it is thus important to define what type of impact we talk about.

The idea of joy was very positively received, it resonated with multiple consortium partners: it is an important point for the reflexivity of the researcher, e.g. what impact they have on the group, not to turn the naturally joyful processes of making into a rigid research project, and remove co-creativity, conversations and experimentation/exploration for the sake of productivity and output.

1.7. PARTICIPATORY AND REFLEXIVE RESEARCH

Maker communities are Communities of Practice (CoP, Lave and Wenger 1991), meaning that they learn, develop projects, and expand on their values as they go: their activities are based in praxis, the pathways are developed through discourse and material engagement. They share a concern or passion for something they do and learn to do it better as they work together regularly (Wenger-Trayner and Wenger-Trayner 2015), making their practices fluid and flexible. These characteristics make it possible that suggested improvements can become embedded in their everyday practice for example by conducting participatory action research (PAR).

Many communities develop their ideas in informal conversations, that often reflect their framings, contexts, etc. – (see e.g. “*nongkrong*” in Pushkin 2020)), and these reflexive conversations are then followed by actual prototyping, based on the spaces and strategies they use, and continuously reflecting the pathways that innovations are created within, both in discursive and material terms (Smith et al. 2016). At the same time, responsible research and innovation is also about the processes of innovating responsibly. While mainstream innovation processes are exploring iterative methods to make their innovations “stick better”, most innovations need to happen fast and create profit as fast as possible. By contrast, grassroots innovators take their time and are often embedded in the community they aim to serve and are developed with them, reflecting RRI principles. Making, and especially critical making, is not a linear process. Innovation

can only work if it's iterative and builds on continuous learning. If we add reflexivity and other process dimensions of RRI to the process, even more feedback loops are included, which can improve the reflexivity of grassroots innovators. Research should reflect this, and the design of participatory research should also reflect the non-linear way of co-creation and co-design and collaboration.

Participatory action research (PAR) has been used since the 1940's, and is especially interesting for the Consortium because in this methods, researchers and practitioners work together to understand a situation and improve it (Kindon et al. 2009). Thus, it can easily be embedded into the existing practices of maker communities. PAR has a focus on social change that promotes democracy and challenges inequality, it is context-specific, targeted on the needs of a group, it iterates research, action and reflection and seeks to "liberate" participants to have a greater awareness of their situation that inspires action (Reason and Bradbury 2012) - it is thus in harmony with the values and practices of many grassroots communities, especially makers. By working closely with the practitioners, we can intertwine outsiders' and insiders' ontology about non-mainstream and bottom-up innovation practices that aim to move away from black-box like, closed-source outcomes and democratize innovation for all¹³.

Fortunately many excellent collections of hands-on PAR methods are available today, for example the Durham University's PAR Toolkit¹⁴ (adapted from Kindon et al. 2007), which outlines the recurrent stages of planning, action and reflection and evaluation in bullet points and key questions the PAR group should address during the research process on collaboration, knowledge, power, ethics, building theory, action, and emotions and wellbeing, supporting reflexivity in research.

Another interesting approach is the reflexive-interventionist, which has been advocated for in HCI in order to be able to create new theories around the maker movement, moving away from neoliberalism and technosolutionism (Lindtner et al. 2016), with backgrounds in feminist utopianism and speculative sociology. In "Reconstituting the Utopian Vision of Making", Lindtner et al. offer two moves. The first move constituting a critique of the

¹³ Links between critical theory and action research for emancipation have also been explored, see Kemmis, Stephen (2001). Exploring the relevance of critical theory for action research: Emancipatory action research in the footsteps of Jürgen Habermas. In Peter Reason & Hilary Bradbury (Eds.), *Handbook of action research: Participative inquiry and practice* (pp.91-102). London: Sage.

¹⁴ Available under <http://communitylearningpartnership.org/wp-content/uploads/2017/01/PARtoolkit.pdf>

present to reveal both problem spots and opportunities for intervention, and practices, spaces or moments where alternatives to dominating modes are revealed, analyzing making without normalizing it in Western terms. The second move is rooted in the critique of the present and employ anticipatory design to move forward. This is reconstructive and works with fragments as raw materials to speculatively imagine and explore alternative futures (ibid. page 1391).

Reflexive interventionist or multi-agent based (RIMA) approaches are also proposed for “wicked problems” (Wilkinson and Eidinow 2008), which is particularly interesting as Critical Making was also originally developed to discuss wicked problems (Ratto 2011). The RIMA approach identifies wicked problems as messy and circular, as there is no definitive statement of such a problem, the perspectives of stakeholders will result in contradictory definitions. Linear problems solving approaches don’t work in these cases, but the consideration of epistemologies in scenario processes, for sense making, might (Wilkinson and Eidinow 2008, pp 2-3). Consensus is not sought around a single understanding of current reality, knowledge is acknowledged as multiple, temporary, and dependent on the context. Scenarios are a mode of action research, used as a basis for unlearning and learning. Scenarios need to be combined with other methods such as weak signals/horizon scanning to maintain vigilance to developments falling outside of the existing scenario set and early warning signs to track indications that a particular scenario is developing (ibid. pp 7-10).

1.8. DISCUSSION/ANALYSIS/SUMMARY

This first part of the report was written to inform the overall strategy of the Consortium, and the 3 case actions. This literature review helps easily navigate existing scientific insights and findings, which can be used in future publications to situate the research. Existing directions of critical can be built upon and learned from. Questions raised by participatory researchers, and their innovative and reflexive methods can guide the research process and ensure that it really invites practitioners as co-researchers.

How maker communities engage in RRI practices, including seemingly hidden or unknown values and underlying assumptions to support reflexivity needs to be unearthed systematically.

While the consortium members are in the process of developing the working definition of Critical Making for this project, a lengthy process based on learnings about the term, but also real-world practices themselves, that will shape the definition. Projects the case

actions will be concerned with will be situated in and navigating complex societal, political, and economic contexts, including projects that express societal critique, such as activist and awareness-raising projects, projects embedded in counterculture: contributing to reflexivity in society, but potentially starting discourses uncomfortable for decision makers. Others might aim to solve societal problems, develop social innovations and attempt to remain seemingly apolitical while doing so. The case actions represent a great opportunity for researchers to dive deeper into diverse critical maker projects, analyze them through participation and in a qualitative manner, and further develop theories on the situatedness of making.

By analyzing their practices with the help of existing theories about the relationships between society and technology, by viewing them through the lens of non-conventional innovation theories, and by deploying innovative types of participatory action research methods, we can better understand and develop new theories of grassroots innovations, and their contributions to reflexivity in society, reflexivity amongst themselves, and we can also contribute to science by developing more equitable research strategies by practicing reflexive methods as researchers. This is what the next sections aims to inspire.

2. CRITICAL MAKING RESPONSIBILITY FRAMEWORK

2.1. INTRODUCTION

As outlined before, the Critical Making consortium is implementing an ambitious research program to explore how RRI in maker communities has the potential to enable society to help shape socially relevant, problem-driven innovation and research processes and ultimately leading to more inclusive and sustainable outcomes thereof. The goal of this framework is to support the consortium's work exploring RRI processes in maker communities. RRI concept is mostly applied in institutionalized research and innovation settings and refers to practices that engage actors in reflection and help highlighting assumptions behind strategies, thus supporting reflexivity and anticipation. There is a need to conceptualize such thought processes also for makers, who, while they do engage in exchanges about values and co-creative thought processes in developing innovations, are known for their community-based material design work. While it generally takes a long time for grassroots movements to become sustainable, such developments can be evaluated retrospectively to be better understood or can be informed by anticipative thought processes and planning for potential futures and a plurality of potential pathways through foresight.

We know from observation and participation that grassroots innovators do engage in responsibility practices, as they advocate for openness, sharing, co-creation, user-centered and community-based design, etc, although these practices are not labeled under the concept of RRI. However, we have very little research-based data on if and how these RRI-related practices are implemented. To be able to really acknowledge RRI in grassroots, there is a need to rethink the concept of RRI from the perspective of grassroots innovators and to develop methodologies to better understand how social responsibility is understood, practiced, and evaluated by them, with a particular focus on

reflexivity, co-productive processes and knowledge production, as well as other RRI-relevant topics such as inclusion, gender and openness.

Our aim is to directly contribute to developing a Critical Making Responsibility Framework which draws the conceptual understanding of responsible innovation from the general RRI framework and the substantial understanding of social embeddedness of maker activities from the grass roots innovation movement studies. The aim is thus to cross-fertilize these two frameworks and to create a framework that is particularly designed to investigate the social responsibility of making. The Critical Making Responsibility Framework will serve as a baseline to develop specific tools for both researchers and policy makers studying and evaluating the social impacts, ethics, and responsibility of making on hand and on the other hand to serve the purpose of developing tools for self-reflection for makers themselves. We build this framework on previous studies on critical making in grassroots innovation practices (R. Sipos and Wenzelmann 2019) and the GIM framework.

This preliminary framework is at this stage the first attempt to explore how GIM and RRI frameworks can cross-fertilize each other and to offer analytical tools to explore different dimensions of social responsibility in making. The framework is to be co-created and co-developed with the communities the consortium works with during the project. As maker communities often work, develop, and think together (see for example the Indonesian term "nongkrong"), grassroots making can be a non-linear and very creative process. What we ask ourselves here is: what happens if maker communities are given or give themselves the tools, time, and permission to think, anticipate, reflect together - before, during or after a project?

While the consortium is still developing their working definition of critical making for responsible innovation activities and practices in grassroots (see chapter 1.6.2. *The Consortium's Working Definition*), the methodological toolbox we co-develop with the practitioners will also contribute to this definition.

2.2. ANALYTICAL-CONCEPTUAL FRAMEWORK: BRINGING GIM AND RRI TOGETHER

This framework outlines how the Critical Making project integrates the four-dimensional, analytical approach on GIM (A. Smith et al. 2016), developed to better understand how they provide a source of reflexivity in society) with participatory, reflexive and anticipatory RRI methodologies (Stilgoe, Owen, and Macnaghten 2013). The guiding principle behind

the framework development is to increase the sensitivity (critical thinking) of both the research team and engaged maker space actors towards the identified responsibility issues (gender, youth engagement, openness) in makerspace activities.

The Critical Making Responsibility Framework thus draws insights from two so far distinct academic fields, RRI and GIM, and based on them provides an analytical framework to explore different dimensions of social responsibility in making and grassroots innovations.

The dialogue between RRI and GIM enriches both fields. It broadens the concept of innovation of RRI discussion towards a wide variety of grass roots activities. For GIM, the RRI approach provides a new perspective on how the GIM conceptualizations can be utilized as part of participatory and forward-looking action research in addition to mere retrospective analysis.

- The co-creative methodology of developing Critical Making Responsibility Framework will bring the practitioners' views as an integral part of framework development.
- The general Critical Making Responsibility Framework provides a basis for specific reflexive tools that are tailored for different user groups. Tools will be developed for researchers and practitioners.
- The Critical Making Responsibility Framework also serves as a basis for developing responsibility evaluation approaches for the purposes of policymakers.

2.2.1. Grassroots Innovation Movements Framework

Practical grassroots innovation committed to values of social justice or environmentally sustainable developments has existed for decades and caught the attention of researchers (see for example (Schumacher 1973, Hess 2009, Smith 2005). As Smith et al. summarize, "we conceive hackerspaces, fablabs and makerspaces as a grassroots innovation movement because there is considerable activity outside formal institutions and because their networks are committed to exploring the social possibilities of bringing tools to people" (Smith et al. 2016 page 100).

Grassroots innovation communities, networks and movements around the innovations create solutions to (hyper)local issues, in bottom-up, self-initiated processes, with a focus on and embedded in local communities and their problems, needs, values, making the solutions often more sustainable than top-down, one-size-fits-all solutions. Innovations are developed cooperatively, through collaborative deliberation, negotiation, and while building trust. They might be born out of necessity, to raise awareness around societal

questions concerning marginalized groups of people, or address issues neglected by conventional innovators, because developing such solutions is rarely profitable. Communities, discourse, knowledge, prototypes, and innovations are developed in the process. They produce knowledge, appropriate technology, and coordinate social organization (ibid. page 6)

Smith and his colleagues (2016) developed an analytical framework to better understand the pathways of development that different GIMs have walked. This framework was developed for researchers to analyse already established GIM retrospectively. The authors argue that pathways to sustainable developments are plural, and they want to know more about how groups and networks address questions of development, how they express relevant values in the innovation activity and what shapes their pathway through that activity. They also claim that broader social visions and implications of developments are made richer by analysing GIM (ibid. p. 5): it is a matter for analysis to understand how GIM provide “a source of reflexivity in society, by pointing to the contention and plurality involved in sustainable developments and opening up more spaces for doing the politics of alternative sustainabilities”. It is this question of reflexivity within the communities and its extension that becomes a source of reflexivity in society that makes this endeavour interesting for RRI.

The main theoretical framework that is guiding us during our work in this project is inspired by this novel, multidisciplinary approach. To understand and analyse grassroots innovation movements and how they co-create alternative visions and practices of development, social movement literature (mobilization of resources and political strategies) is used alongside science and technology studies (STS) and innovation studies (concepts about learning, knowledge creation and technological innovation) (ibid, p. 18).

The GIM framework suggests analysing 4 interrelated concepts to understand grassroots innovation movements: broader contexts, framings, spaces and strategies and pathways.

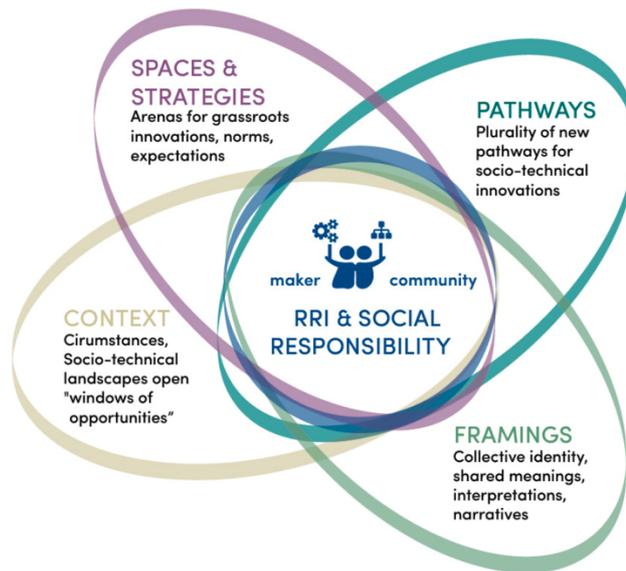


Figure 5 Critical Making Responsibility Framework

In the sphere of context, circumstances are mapped by utilizing a multi-level perspective (Geels and Schot 2007), where “windows of opportunities” for a particular makerspace are identified in niche level innovations, variables of sociotechnical regime and socio-technical landscape developments. The context helps outline the conditions in which the movement is developing: historical, political, economic, cultural, religious contexts that could be generative or constraining, and other circumstances, issues and situations, including opportunities available within those contexts that had a generative effect on the movement.

In framings, future possibilities are negotiated collectively, including establishment of shared vision(s). Framing is the process of meaning production that helps communities connect to powerful narratives beyond shared grievances which can be expressed in critique towards mainstream practices. Framings are shaped by underlying assumptions, and can include problems, strategies, requirements, theories, knowledge, design criteria, exemplary artefacts, testing procedures and user practices that emerge through social interaction. While it can include technological frames (free/open source software, free/open source hardware, peer production, personalized manufacturing, mass customization and a new industrial revolution, the democratizing power of technological citizenship), it also can include or exclude a broader set of framings, such as social, economic, or political questions and can be important factors in how they design their practices.

Spaces and strategies crystallize novel strategies and co-operative forms. What actions communities take, and how those actions are influenced by the availability of resources is explored here, considering that spaces can not only be physical, but also social, discursive and institutional (makerspaces are spaces for grassroots digital fabrication, maker movements and grassroots groups, activities include educational outreach and skills provision, etc). Locations and activities that enable them to do experimentation and innovation differently are analyzed, actions done by enrolling audiences, alliances and users to improve their own performance (in a user-centered way, creating public engagement) and making alternative spaces of engagement. It is hereby that resources are mobilized while grassroots consider the costs and benefits, risks and rewards of strategies, shaped by the conditions attached by resource holders that influence the outcome of their activities ((A. Smith et al. 2016), p. 26).

In the pathways section, various opportunity pathways are constructed and assessed from multiple perspectives. How does the plurality of pathways contribute to alternative developments over time? Ideas and aims are continuously developed, and dismissed; objects and practices and their materiality also contribute to developments in different and changing settings over time, including a future perspective. These alternative pathways and their plurality shows that there is not just one self-evidently best pathway, and the political nature of grassroots movements might contribute to new pathways created with greater attention to issues of social inclusion, diversity and difference and social justice, playing a key role in their RRI practices (ibid, p. 28).

2.2.2. RRI in Grassroots and Procedural Principles

The core idea of critical making and the need to increase the reflexivity and social responsibility of grassroots innovation movement suggested by GIM framework resonate clearly with the concept of RRI which draws from the tradition of STS debates on the need to recognize that although science and technology development have enhanced well-being, they have also created unintended consequences, including climate change for example. In addition, many of the outcomes of science and technology development are controversial and have become matters of social concern as public discussions around issues such as genetically modified organisms (GMO), data economy and automated traffic show. RRI was developed a decade ago as a response to the need to deliberate the values embedded in the process of science and technology development and to provide a responsibility framework for research (e.g. Gianni et al. 2019). Thus, it is

primarily a tool to govern the socio-ethical aspects (Scholten and Blok 2015) of research and innovation.

RRI as a concept refers to strategies and practices which enable researchers and a variety of stakeholders to become mutually responsive to each other and to anticipate the societal impacts of the outcomes of research. It is understood as “a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the acceptability, sustainability and societal desirability of the innovation process and its marketable products” (Schomberg 2011) What is to be noted is the importance put in the continuous engagement of citizens and civil society during the innovation process to negotiate the value of its outcomes. This means that RRI principles aim to integrate practices of anticipatory governance into the innovation process (Felt 2018).

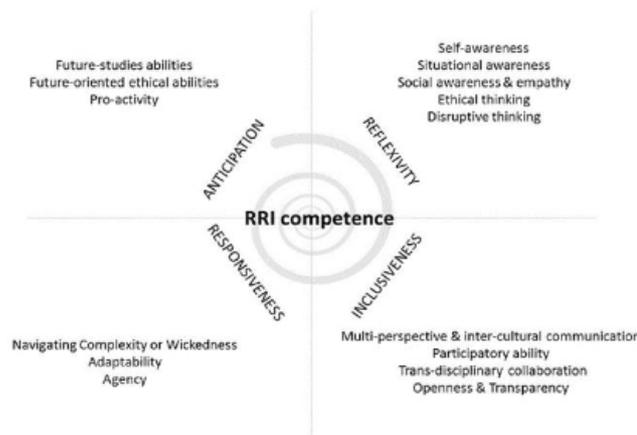
According to (Stilgoe et al. 2013), anticipation and forward-looking thinking together with collective stewardship is a key factor of responsible innovation. They define four key dimensions for RRI: anticipation, reflexivity, inclusion, and responsiveness. These dimensions, which are well-aligned with the idea of social responsibility manifested in the GIM framework, have been increasingly adopted in the evaluation and monitoring practices of scientific research by research funding and performing organizations. For this purpose, RRI has been operationalized to six separate policy keys (see figure: gender, governance, ethics, stakeholder and public engagement, science education) and related indicators to be used in evaluation (eg. MoRRi, SuperMoRRi,). In addition, different RRI tools to targeting the design and implementation of research process and to increase the sensitivity of research teams along the on-going work towards ethical issues and social responsibility have been developed (eg. New HoRRiZON social readiness tool)

So far, these tools have been mostly designed for institutionalized research and innovation. Following from that, it has been claimed that despite reflecting similar goals with both citizen and industry-driven pro-social innovation movements, the RRI discourse has remained mainly isolated from it. Furthermore, it has also been criticized of being a Euro-centric approach (Bhaduri and Talat 2020) designed for the societies and innovation systems of the Global North. Following from that, several scholars have claimed that the concept of RRI fails to recognize such conceptualizations of innovation which arise and are addressed towards the Global South including for example frugal and grass roots innovations (Mamidipudi and Frahm 2020). According to Bhaduri & Talat (2020), these innovations develop in contexts which differ significantly from R&I practices

of established research institutions and companies which means that the concept of RRI is not adoptable as such. As the sites of frugal and grass roots innovations are diverse ranging from social collectives to informal enterprises, also the understanding of dynamics of innovations and their social embeddedness needs to be revised and enriched with context specific knowledge. For example, Bhaduri & Talat claim that frugal innovations are by definition responsive to societal needs and values as they are directly developed by the people and communities for the purposes of these same communities. The Critical Making project aims to bridge this gap by integrating the anticipatory and reflexive RRI tools to the GIM analysis to create a Critical Making Responsibility Framework, which is particularly tailored for the purposes of researchers engaging makers in their activities and makers to foster their responsibility culture and practices.

The simplifying of RRI in the six key dimensions and general questionnaires have also raised criticism of failing to grasp the deliberative character of RRI. The on-going debates on the definition, essence, and different uses of RRI indicate that it is a flexible concept and framework open to interpretations and context specific tailoring. To adopt the RRI principles in the context of citizen-driven innovations, maker spaces and community-based innovations, we will focus on the procedural insight offered by the RRI approach (see figure) and explore how the principles of anticipation, reflexivity, inclusion and responsiveness can be concretized into a Critical Making Responsibility Framework by specifying their definitions with the help of GIM dimension inviting us to pay attention on the context, framings, spaces and strategies and pathways which shape the present and the future making activities but are also at the same time shaped by them.

RRI Competence



Tassone, V.C., O'Mahony, C., McKenna, E. et al. (Re-)designing higher education curricula in times of systemic dysfunction: a responsible research and innovation perspective. *High Educ* 76, 337-352 (2018)

Figure 6 RRI Competences

Stilgoe (et al. 2013) define the four principles in a following way:

Anticipation: refers to systematic thinking which aims to increase resilience of communities and helps to recognize and create opportunities for challenging the existing state of the art with novel social and technical innovations. Anticipation can be fostered with various participatory and deliberative foresight tools including horizon scanning, scenario building and road mapping. The aim is also to make people aware of existing social imaginaries.

Reflexivity: refers to deliberate rethinking of how one's activities encounter and reflect the social norms and conventions and potentially challenge or strengthen existing social power relations, division of labour and costs and benefits or whether it causes potential risks for other people or ecological environment. Reflexivity is a process of questioning one's own activities and looking at them from the perspective of other people and natural beings.

Inclusiveness: which is the third RRI dimension refers to the need to include multiple voices and stakeholders in the research process both to bring in legitimacy for research and to increase the outreach of research but also to provide an opportunity for stakeholders to express their concerns and opinions about the direction of research. Several engagement methods to achieve inclusion have been introduced in research literature including for example citizen juries and panels or more light consultation through surveys and polls. In addition, participatory research methodologies engage people directly to scientific process. Open innovation and use-centred design also aim to include lay people directly in RI. What is important in designing citizen engagement is the need to carefully consider the multiplicity of voices and to make sure that also often underrepresented citizen (eg. elderly people, young people, people with lower socio-economic status etc.) groups are invited and can become heard in various deliberative settings.

Responsiveness: The ultimate aim of the three previous RRI principles is to increase the capacity of researchers and science and innovation system to be responsive for social challenges related to their research. In institutionalized research this kind of responsiveness is shown for example in the direction of research efforts towards recognized societal challenges. In addition, research actors can actively influence the rules of the game in society by promoting changes in regulation and standards and contributing to on-going policy debates and programs.

2.2.3. GIM and RRI: Critical Making Responsibility Framework

As described in the previous section, the procedural RRI criteria is developed for institutionalized RDI actors and basically for the socio-technical systems of the Global North. Therefore, although we take the four procedural RRI dimensions as a starting point to develop the Critical Making Responsibility Framework, we need to reconsider the meanings of these dimensions when applied for making and grass roots innovations. For example, according to (Bhaduri and Talat 2020) grassroots innovations are usually incremental with little risks which means that broad foresight processes are not relevant and often too heavy in these contexts although anticipation is still a meaningful activity. In addition, also reflexive processes need to be designed in different ways and question of inclusiveness gets different meanings at the grass roots level than in institutional research contexts. For this adoption, we need the dialogue between RRI and GIM conceptualizations.

The analytical conceptualizations of GIM are originally developed for researchers to understand the dynamics of social. In that sense, it provides an outsider's perspective to grass roots innovations. Currently, it is not used to support grass roots processes or as part of participatory action research. While combining it with the procedural criteria of RRI, we want to elaborate this framework towards a reflexive tool that is useful for both researchers interested in multiple dimensions of social responsibility in making but also for practitioners to support their reflexive processes. Following from that the combining of the general RRI principles with the GIM insight on grassroots innovations as a social movement will also enrich both theories. For the RRI discussion, it broadens the concept of innovation which has so far been restricted to institutional innovation settings. For the GIM community, it provides new approaches for future-oriented participatory action research.

Our guiding principle behind the development of Critical Making Responsibility Framework is thus not to merely bring or impose RRI thinking into making. Instead, we want to create a new responsibility framework that is particularly tailored to capture the responsibility issues that are relevant in making and grass roots innovations and respect their character. Therefore, while elaborating the Critical Making Responsibility Framework, we will keep in mind the need to respect the emergent character of bottom-up innovation activities. The key question is how to advance the reflexivity and social responsiveness and at the same time keep up the playfulness and curiosity of making.

2.3. DEVELOPING THE CRITICAL MAKING RESPONSIBILITY FRAMEWORK

In this first phase of the project, the goal has been to bring together the analytical, retrospective GIM framework and the RRI principles through conversations between consortium members who are experts in these tools. We wanted to understand and explore which dimensions align with each other and which might not, based on the experiences of the researchers. A 4x4 matrix has been created based on 4 dimensions of GIM (contexts, strategies, framings and pathways foster responsible innovation processes) and 4 dimensions of RRI (anticipation, reflexivity, inclusiveness and responsiveness). These serve as instruments to systematically analyse if and how responsible critical making is supported and practiced. This can be further developed later into one or more practical tools for academic researchers, but also to be made accessible for non-academic co-researchers, policy makers, and grassroots innovators.

An important initial step is also to bring different disciplinary terminology to a common understanding as we intend to combine concepts stemming from distinct disciplinary backgrounds. For a common approach terminology is crucial. While terms and concepts like “context” and “framings” or “anticipation” and “reflexivity” might be terms researchers of a particular discipline might immediately understand, such terminology is not necessarily accessible for researchers of other disciplines and other non-academic actors who might be interested in using the methodological tools developed in the project.

Thus, the first step in further developing the RRI framework for research about and with GIM has been deciding on a 4x4 matrix to be able to combine each of the dimensions. Then, interdisciplinary researchers (with experience in GIM and/or RRI) shared experiences to explore the feasibility and opportunities of developing the matrix and engaged in discussions on its usefulness and practicalities of implementation.

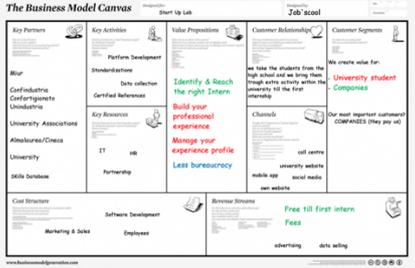
The aim of these exchanges has been to create a preliminary “loose framework” of short descriptions of anonymized examples from our field research. A preliminary overview that will be further developed in the next steps can be found in Annex 2.

2.4. OUTLOOK

In the next phase, we will validate and elaborate the descriptions with the field actors to get their insights on the relevancy of suggested responsibility dimensions. After we have the general framework ready, we move on to develop specific tool sets (concrete

questions etc.) for 1) researchers that engage makers in participatory action and for 2) grassroots innovators in the field (e.g. makers). To create a self-reflective tool for people and communities who ask themselves whether their practice is sustainable, responsible, etc. and also to provide a tool for researchers and policymakers who want to assess the responsibility of particular actions.

The Critical Making Responsibility Framework is thus to be further developed into hands-on tools, tested and iteratively developed in the case actions. Aside from developing a questionnaire for self-evaluation and planning, preliminary ideas for accessible, easy to use, hands-on, visual tools include:

<p>Existing RRI reflection tools to provide ideas of what types of questions can support forward looking thinking and address relevant responsibility issues.</p>	 <p>https://newhorizon.eu/thinking-tool/</p>
<p>Interactive cards to support reflection</p>	 <p>https://padlet.com/enollorg/TipTrickRRI</p>
<p>A visual, color-coded tool that “fans out” to inform the self-led interview, and further questions are revealed</p>	 <p>https://thechalkboardmag.com/the-feelings-circle-chart-emotional-communication#sl=1</p>
<p>A canvas, similar to e.g. the “Business Model Canvas”, to be filled out in groups using post-its</p>	 <p>https://medium.com/@internscool/business-model-canvas-72b829455f8c</p>

The medium will be decided upon together with the practitioners and tested and iterated together with them, and the language will go through further “translation” processes to make the tool accessible, available in non-academic language and to be made hands-on

and practical to be used before (for planning), during (for reflection) and after (for self-evaluation) any grassroots project or program.

3. METHODOLOGICAL TOOLBOX

3.1. INTRODUCTION

The critical making project has been designed to be participatory. For each of the 3 focus areas (gender, young talents, openness), we co-design and pilot participatory case actions. Each case action is led in partnership by an academic partner and a practice partner as case actions will be based on participatory action research principles. In combining science and practice we follow a truly transdisciplinary research approach, approximating from a socio-technical perspective through a co-creative collaboration between actors and researchers. In this toolbox, we collect potential methodologies that support the case actions, and we synthesize and build upon relevant academic and grassroots frameworks. These will be used to understand RRI in maker communities – and together with them. The aim is both on the researchers' and the makers' side is to become more sustainable, reflexive and develop critical thinking skills through material practice.

As a preliminary version of the toolbox, in this baseline document, methods have been collected that show co-researchers how to design research processes and spaces that do not intercept naturally developed innovation processes within grassroots and that take enough time to create trust and safe spaces for exchange for the co-researchers to be able to learn from the communities they work with. Many researchers participating in the project have already engaged in participatory methods that enable discussions, such as world café (Sipos and Wenzelmann 2021), participatory action research (ZSI and GIG in the projects CoAct and Careables), and various foresight methods (see Jouko Myllyoja's input below (VTT)). To learn and get inspired by different methodologies, reflexive-interventionist researchers were invited to the co-design workshop, who were asked to share short outlines of their practices in addition to the video recordings, in an accessible language so that makers can also get inspired.

3.2. METHODOLOGY

The methodological toolbox is designed as a living and interactive collection of reflexive and interventionist tools supposed to help the work of researchers, but also the work of grassroots practitioners. For now, it is a non-interactive, preliminary version of tools.

In addition to the preliminary version of an interactive tool that is based on the theoretical-analytical framework outlined in chapter 2, in this 3rd chapter, two preliminary tools are offered. First, the Sustainable Making Principles, which were developed by grassroots innovators to guide their own work and is being further developed in the work of the consortium into an interactive slider tool, in exchange with the practitioners. Second, various research approaches that are participatory, community-based and reflexive are outlined, based on short summaries of the researchers' presentations at the co-design workshop. To ensure that these outlines are useful for non-academic practitioners, they were asked to provide very practical tips on how the methods can be used outside of academia and in maker communities. Finally, the work of the case actions is also supported: inspiration coming from grassroots during the co-design workshop, discussions around potential research questions and methods have also been taking place with researchers in the case actions, these are also briefly summarized. Social responsibility, ethics and other relevant aspects related to responsible innovation are considered across the three case actions

It is important to repeat, that these tools are to be further developed in the case actions, with the practitioners, throughout the project. This collection of participatory tools and methods will be tested, iterated, and further developed with the co-researchers and grassroots innovation practitioners in participatory research projects.

3.3. SUSTAINABLE MAKING PRINCIPLES: SLIDER TOOL FOR SELF-EVALUATION

In December 2019, an international group of makers gathered at the annual conference of GIG¹⁵, and driven by the inquiry "whether and how makerspaces across the world can

¹⁵ Global Innovation Gathering (GIG), a global community of innovation hubs, makerspaces, hackerspaces and other grassroots innovation community spaces and initiatives as well as individual innovators, makers, technologists and changemakers. The annual conference is called

become centres for positive social and ecological impact, while integrating models that ensure financial self-sufficiency”, developed a set of Sustainable Making Principles (Nuesse and Wanalo 2019). Inherently, these strongly relate to RRI principles, with a greater shift towards socially responsible open innovation:

1. **Make** things that make sense: Create products and solutions that solve fundamental, real-world problems.
2. **Integrate** Local Knowledge: Design with the community, leveraging on local knowledge and experience, as well as the local resources & assets available.
3. **Include** Ecosystem Services: Aim to give back more than you take from the environment and include accounting practices that value the natural resources used.
4. **Build** for Continuity: Design for the present and future; build social capacity & aim for financial self-sufficiency.
5. **Share** How You Make: Develop a set of guidelines that provide a framework for openly documenting everything about the making of the project.

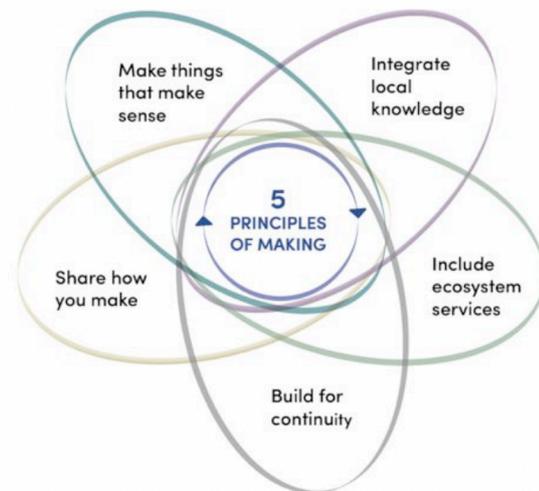


Figure 7 Sustainable Making Principles

We are including these principles of sustainable making in our analytical frameworks of and for the social responsibility of the maker community and are proposing a tool based on the principles as well as the Critical Making Responsibility Framework (Chapter 2). The tool will be continuously developed with the GIG network and other maker communities, meaning for and with grassroots actors. Conversations about “meta topics” are often regarded as tedious by practitioners, therefore gamifying the experience is attempted and enable users to not discuss all topics in one session but focus on different topics at different times. It is important that the tool can be used offline, therefore we create a printable version including instructions (potentially to be shared on Wikifactory, github (an online open hardware repository), or the website of the project). An online version will be made available on the Critical Making website. Screenshots of the first version is below, while the digital version can be found under https://miro.com/app/board/o9J_lAYLH5k=/

DOTS, and participants came from Germany, Brazil, India, Iraq, Kenya, Singapore, Sri Lanka, and South Sudan <https://www.globalinnovationgathering.org/dots/>

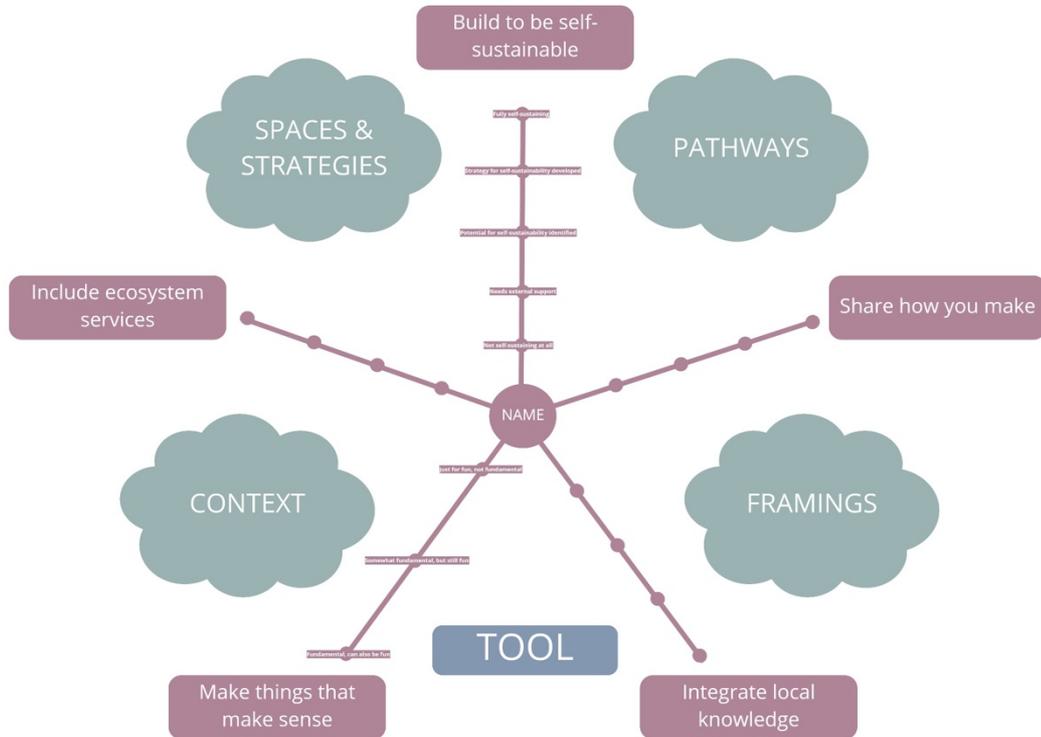


Figure 8 Sustainable Making Self-Evaluation Tool

<p><i>Make Things that Make Sense</i></p>	<p>Make Things that Make Sense</p> <p>GUIDING QUESTIONS</p> <p>What is the nature of the problem you are tackling?</p> <p>Is your solution going to have a fundamental impact - or is it a rather for fun project - or both?</p> <p>EXAMPLES</p> <p>3D printing Yoda heads is fun and can have a fundamental impact when done to teach 3D printing. 3D printing prostheses is fundamental.</p>	<p><i>Build to be Self-Sustainable</i></p>	<p>Build to be Self-Sustainable</p> <p>GUIDING QUESTIONS</p> <p>How much do you depend on external support?</p> <p>How clear is your strategy for becoming self-sustainable to your community?</p> <p>EXAMPLES</p> <p>A makerspace with a proven working business model is fully self-sustaining. A group of makers who are just starting to create a community is not financially self-sustaining at all. Most will find themselves somewhere in between.</p>
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Figure 9 Cards with Guiding Questions and Examples

While developing this preliminary tool, we have encountered the following challenges. The first challenge is based in the differences between the merged frameworks: while the

aim of the Sustainable Making Principles is to support makers in reflecting on questions such as “Is what we are making, making sense?”, the Critical Making Responsibility Framework creates space for discussions on the broader contexts, framings, spaces, and strategies and pathways in which the maker community develops sustainably. The tool reflects this difference, and explicitly opens discussions about the relations between the principles and the framework. Such an example would be: how might the broader context impact what relevant categories could be defined for potential levels of “including ecosystem services”? The second challenge is posed during the “translation” of academic wording to the users of the tool, who are grassroots practitioners. We therefore created questions which can guide self-reflective conversations as part of the tool, but we will be reviewing these with the practitioners. The third challenge is the quantification of qualitative categories, we asked ourselves: what do you measure for example when measuring “how much” you Share How You Make? The required mindset for reflection is fundamentally different from linear Key Performance Indicators which have become the norm in (self-)evaluation processes. We therefore propose that communities do not measure e.g. “how much” they share, but how much effort they put into making what they share accessible to others. The final challenge is that self-reflection does not work without outside feedback: no maker or community can know the level of integration of local knowledge without feedback from other local knowledge holders. Therefore, we regard the tool to enter such conversations with the wider local community and ecosystem and will be defining its best use together with the practitioners.

This tool aims to support people and communities who ask themselves whether their practices are sustainable and responsible. Such a tool for reflection and self-evaluation itself requires constant reflection and evaluation, as well as adaptation to different circumstances of different communities. Therefore, the first iteration of is being made available openly and shared with global maker communities, explicitly asking them to remix, adapt and discuss it. The next step in the project is to host self-reflective sessions with makers who are entering the Critical Making Open Hardware Program. In these sessions, we will gain insights, collect feedback, develop recommendations, and include examples on how each dimension can be adapted and improved. A second round of reflection sessions at the end of the program will enable us to analyze changes through the program. Finally, it important to note that the principles addressed in the tool might not be exactly applicable to the critical making definition used by the project, however, they provide us with a starting point on how grassroots see and assess their own sustainability.

3.4. 4 PARTICIPATORY APPROACHES

To help the participatory research work of the case actions, and to explore different methods, the project invited researchers who use such methods in their academic and non-academic research to share their experiences in the co-design workshop, which were then discussed and organized in an internal follow-up workshop.

Below, short summaries of participatory methods used by experienced researchers and practitioners are introduced. These are summarized as bullet points, and in the next project period, such and similar, inspiring approaches could be turned into digital cards (similar to baseball or pokemon cards), to help inspire the research design process through gamification, of course, without oversimplifying the methods themselves.

As the researchers shared their insights at the co-design workshop in brief presentations, these are available as videos online. The links to these are included below, therefore only short summaries of some key points about the methods are shared below.

Future-oriented participatory foresight and drama methods	
Jouko Myllyoja (VTT)	
<p><i>Short description</i></p> <p>foresight methods, such as imaginative perspectives through drama and shared vision building, roadmapping, and possibilities that the innovation ecosystem approach captures within foresight. Futures building was presented as a learning process that builds on collective and participatory questioning and exploration of alternative futures.</p>	<p><i>Key points</i></p> <p>Foresight methods: action-oriented and participatory strategic thinking that focuses on potential and alternative perceptions of the future, and these (e.g. imaginative perspectives) can be developed through drama.</p> <ul style="list-style-type: none"> • Qualitative, systematic, participatory, and multi-disciplinary nature, a space for different stakeholders and experts for systemic thinking and developing future-oriented knowledge. • Futures building as a learning process that builds on collective and participatory questioning and exploration of alternative futures. Innovation ecosystem approaches can be used, such as vision building or roadmapping. • Creating a shared vision and action paths towards the vision, by exploring different, possible futures of the subject matter collectively.

	<ul style="list-style-type: none"> Combining different working methods to acquire and process data is possible, these could include office work, workshops, web inquiries etc. <p>Drama methodologies: action-based, embodied, participatory way to imagine, simulate and design the realities collectively</p> <ul style="list-style-type: none"> Subjective insights, nurturing imagination and creating inspiration, novel knowledge through differentiated, polyphonic discussion/dialogue
<p><i>Recommended reading</i></p> <ul style="list-style-type: none"> Ahlqvist, T. (2015). Foresight. In: STRADA - Decision-making and support of change in complex systems. Nieminen, M. & Hyytinen, K. (Eds.). VTT TECHNOLOGY 218. Brien F. O. & Meadows M. (2007). Developing a visioning methodology: Visioning Choices for the future of operational research. Journal of the Operational Research Society, 58, 557 - 575. Hancock, T. & Bezold, C. (1994). 16 Possible futures, preferable futures. Healthcare Forum Journal. 37 (2), 23 - 29. Wiek A. & Iwaniec D. (2014) Quality criteria for visions and visioning in sustainability science. Sustainability Science 9:497–512. Ackroyd, J. (2000). Applied Theatre: Problems and Possibilities. The Applied Theatre Researcher, Number 1, 1443-1726. Mackey, S. (2016). Applied theatre and practice as research: polyphonic conversations, Research in Drama Education: The Journal of Applied Theatre and Performance, 21:4, 478-491. Preston, S. (2016). Applied Theatre: Facilitation: Pedagogies, Practices, Resilience. Bloomsbury Publishing. 	
<p><i>Video</i></p> <p>https://www.youtube.com/watch?v=6p2btikKYP8&list=PLUGM9odWOqO6tuX9lZxcluqzrec4fKV3N&index=4</p>	

<p>Experience-centered design</p>	
<p>Dr. Reem Talhouk (Northumbria University)</p>	
<p><i>Short description</i></p> <p>Experience-Centred Design as a critical approach for design and innovation that counters</p>	<p><i>Key points</i></p> <ul style="list-style-type: none"> ECD as enabler to understand people’s experiences and the experiences they aspire for while also understanding the

¹⁶ Possible futures, preferable futures. Healthcare Forum Journal. 37 (2), 23 - 29.

<p>neoliberal approaches to the digitalization of humanitarian services that aim to improve health and food security. The talk was based on Design research she has conducted with refugees in the Middle East and Europe.</p>	<p>social, political, cultural and economic factors that shape lived experiences.</p> <ul style="list-style-type: none"> • Dialogical, empathetic and responsive approach to design that aims to engage with people’s beliefs, values and experience. • The designers’ role is to facilitate the development shared understandings of everyone participating in the design process, including the designer themselves. • Criticality is in line with decolonial design that continuously questions and challenges Western approaches to design and innovation. • Co-design is key: spending time with people negotiating the design endeavour, design tools and methods. • Socializing is a major part of the design process, especially at the beginning: enable everyone participating to reach a shared understanding of each other. • Critical reflection is necessary, and to continuously engage in critical reflection along with the participating people. The practice is shaped by our identities, beliefs and values but also by the people we are working with, the researcher has to be open to changing it. • Considering the value of co-created artefacts that are not related to the final design but rather are made along the design journey, and design outcomes are to be oriented towards supporting participants while configuring interactions in which they have more agency.
<p><i>Recommended reading</i></p> <ul style="list-style-type: none"> • McCarthy, J., & Wright, P. (2015). Taking [a] part: the politics and aesthetics of participation in experience-centered design. MIT Press. • Jayne Wallace’s work on ECD 	

<ul style="list-style-type: none"> • Altorki, S., El-Solh, C. (1988). Arab Women in the Field: Studying Your Own Society (Contemporary Issues in the Middle East)
<p><i>Video</i></p> <p>https://www.youtube.com/watch?v=fRI14ULfcKw&list=PLUGM9odWOqO6tuX9IZxcluqzrec4fKV3N&index=5</p>

Reflexive handcraft-based practice	
Dr. Angelika Strohmeier (Northumbria University)	
<p><i>Short description</i></p> <p>Working collaboratively on in-the-world projects that engage people at all stages of the research process to engender change towards more just worlds. Some of this work related to the digital augmentation of traditional craft practices is explored in her forthcoming book 'Digitally Augmenting Traditional Craft Practices for Social Justice: The Partnership Quilt'.</p>	<p><i>Key points</i></p> <ul style="list-style-type: none"> • Thinking about the making practice in multi-layered ways, unpicking topics of research and the practices and methodologies that underpin the work. • Working with organisations and communities who support or are made marginal in our world, to tell stories, unearth injustices, and co-develop systems of support • Handcraft represents layers of meaning of their services and how the technologies and research projects supported these. • The theoretical writing about the participatory research projects can relate to methodology, researcher responsibility, and notions of care, materiality, and justice, as well as research relationships, and the 'finishing' of projects – leaving research partnerships, including open ended issues; unfinished emotional business; and some threads of the relationships might continue after the project. • The handcraft materialises a longstanding relationship with the issue; thinking about the ways in which participatory research practice often flows in spirals. • Looking beyond the seams of the work – to explore the meaning of stitches, the intentionality of colour, material, and

	<p>stitch length, and being metaphoric in our understanding of the process involved in making the pieces.</p> <ul style="list-style-type: none"> • It is necessary to put aside the strict rules of craft, even if just momentarily, to try new approaches, work across disciplines, boundaries, and media.
<p><i>Recommended reading</i></p> <ul style="list-style-type: none"> • feminist Science and Technology Studies: de La Bellacasa, M.P., 2017. - Matters of care: Speculative ethics in more than human worlds (Vol. 41). U of Minnesota Press. • textiles and craft literatures: Shercliff, E. and Holroyd, A.T., 2020. - Stitching Together: Participatory textile making as an emerging methodological approach to research. Journal of Arts & Communities, 10(1-2), pp.5-18. • philosophies and practices of feminist and justice-oriented ways of working: Asad, M., 2019. - Prefigurative design as a method for research justice. Proceedings of the ACM on Human-Computer Interaction, 3(CSCW), pp.1-18. 	
<p><i>Video</i></p> <p>https://www.youtube.com/watch?v=PEXkSjwdrWI&list=PLUGM9odWOqO6tuX9IZxcluqzrec4fKv3N&index=3</p>	

<p>Divergent Futures of Making</p>	
<p>Sename Koffi Agbodjinou</p>	
<p><i>Short description</i></p> <p>The aim is to shift preconceptions around learning and worldmaking by deeply questioning centuries of enforced beliefs in a particular idea of progress and its underlying political, social and anthropocentric philosophies, which divorced our imagination from holistic and enduring conceptions. Makerspaces here are incubators of divergent futures, i.e. tech-hubs configured as a popular school of design resolutely open to its environment as whose objective is above all to be a radical device</p>	<p><i>Key points</i></p> <ul style="list-style-type: none"> • Critique of subtle mechanisms of R&D by which false reality, false freedom, false determination is created. • Addressing issues of mega-cities, "Colonat" as the possibility of a final form of coloniality. • HubCit�: an experimentation of a modality for the development of technological environments that do not reduce the potential of connection (with nature and with the group). • Lom�, Togo: people as smart citizens or antibodies to the future problems of the city which, imbued with a sense of digital collectivism, would impose the conditions

for global critical questioning of modern human societies.

and the screen of openness, inclusiveness and redistribution of everything.

- The city of tomorrow projected onto the framework of a fractal network of innovation places, each of which would have the vocation to transform its environment (the radius of 1-2 kilometers around).
- WoeLabs: free tool for education, giving the means to residents and the surrounding young populations to develop their own imaginary, share, and be immersed in with open source resources, to the stakes and potentials of technology (IoT, AI, data, blockchain) and addressing urban issues such as waste management, resource availability, mobility, etc.

Video

<https://www.youtube.com/watch?v=8YrEc3zY1w&list=PLUGM9odWOqO6tuX9IZxcluqzrec4fKV3N&index=6>

3.5. CONSIDERATIONS FOR RESPONSIBLE RESEARCH

After the presentations, an internal workshop took place, in which we summarized and reviewed possible methods shared in these 4 presentations that the members deemed useful for conducting research in the project. These include methods and how a responsible researcher is to conduct the research.



Figure 10 Screenshot of the collection board of participatory methods

Methods:

- Borrowing from user research to develop maps, understand the feelings, struggles, desires of other people in a methodological way. Diaries also put the user in charge and gives them autonomy over what they want to share and what not
- In terms of drama and theatre-based research methods, the key learning was that there are participatory activities that emerge from applied theatre. A specific topic is defined beforehand, and the workshop itself aims to create the sense of equalness: no references are made to organizations, no last names are used, and the focus is on what the shared aims, commonalities are that unite the participants. This equalness is echoed in terms of gender, race, sexuality, and other categories to allow for critical reflection based on an awareness of power relations
- Methods of constellation can be used, meaning that people use their own bodies to position themselves in the room around questions and topics to highlight new, previously invisible relations

The researcher's behavior:

- Regardless of which methods are used, this should be done in a very sensitive and reflexive way and allowing for transformative learning on both "sides".
- Participatory observation: is important that the researcher defines interview methods with the interviewees, and in general, projects are co-developed and co-evaluated from the start so the right methods can be found together.
- The responsible researcher uses mirroring and active listening (e.g. sharing interview insights with the interviewees before publishing these), or spends together time in silence, to allow for real engagement to happen.

3.6. OUTLOOK

The goal of the methodological toolbox is to collect methods and tools that can inform the work of the case actions. As this is a preliminary collection of participatory, reflexive and critical input, the toolbox still has a long way to go. Throughout the next 2 years, these will be tested, iterated, developed to see which situations these are particularly useful in, for which audiences, and the maker community itself will be involved in the process to ensure that the key target audience benefits from this work.

The ultimate goal is to design a methodological toolbox containing interactive tools that can be used offline and online to inform reflexivity and criticality in responsible research and grassroots innovation. Digital and analogue versions will both be key as the digital divide and vaccine-divide will most probably not be resolved during the duration of the project, but access and equity need to be ensured. These versions will be designed to be modular, flexible and dynamic. Usability and a visually appealing design will be key. and enabling input and key learnings from the case actions.

The development of the tools over time is to be ensured through participatory action research in the case actions and through the usage of the toolbox in midterm and end of project evaluations. In the long term, it will remain an evolving open access toolkit for STS and other researchers and to be used by grassroots innovators seeking to improve their own practices, bringing more reflexivity to all critical making practices.

Regarding the individual case actions, participants in the co-design workshops shared a lot of questions, recommendations, ideas to think about (these are summarized below in Annex 3). Discussions were held about how the researchers can also build more reflexivity into this for themselves, but also for the participants: how can they engage in criticality, reflection, responsibility, for example about the fact that participants and beneficiaries are not mere “empty vessels waiting for the innovation”. The developed solutions also need to be sustained, it is important not just to leave something behind, and take from the beneficiaries. Based on the input from reflexive practitioners, there is a need for internal reflection about what do we build into our own processes and how? E.g., how does our Western perspective influence our own research? For WP4, it still needs to be explored how we define critical making for education: is it about fostering reflexivity, critical thinking, or help express criticality towards something and spark conversations? How is making utilized to support learning and thought processes, is failing allowed? For WP 5: openness and criticality are highly situated and depend on access, there are

differences between the practitioners' starting points and ways of thinking. Whether it is a question of tools (how to document reproducibly, where to share the blueprints) or methods (e.g. sharing openly and non-competitive hackathons), remains a question to be explored. These questions also inform the design of the pilot incubator: What does openness mean for criticality when currently most blueprints are not useable for reproduction? If people want to share openly, how does that need to happen and what would make it really *open*?

4. SUMMARY

The baseline document summarized theoretical frameworks that can help researchers analyze and theorize the relationship between technology and society, both in Western and non-Western, e.g. in settings of postcolonial computing, to be able to better understand grassroots innovations in maker communities where the "global assemblage" does not allow for one unified description of their activities, but is highly situated in local contexts, resources, and political settings. Making looks different everywhere. Critical making will look even more different.

As this project is developed by an interdisciplinary team which includes researchers, but also people working with grassroots innovators and practitioners, the project has been built on access to and experience working with grassroots. Access to this diverse "global assemblage" of grassroots innovation movements is thus not an issue. However, critical making is not a term that grassroots innovators are necessarily aware of or identify their practice as; in fact, even making is a term that some are not familiar with. Terminologies have been explored but attention was also drawn to a better way: asking the communities what they call themselves and their practice, before labelling them. In addition to the terminology, the innovations done in grassroots remain out of view academia, in a scattered, local, and periodic manner, the infrastructuring processes of "naturally" developing grassroots projects (without any intervention from academia) thus remains difficult to access.

To be able to meaningfully engage, critical and reflexive, action-based and interventionist methods have been explored, some of which utilize critical making as a method of engagement. Such approaches also give the researchers an opportunity to experiment,

learn, and engage even more closely with the communities they attempt to improve the lives of.

Researchers need to be careful because power imbalances can cause issues, and meddling in grassroots activities is seen as problematic by many grassroots innovators (e.g. that the researchers only “take” from them while they deliver unpaid work). The project promises to assess and improve reflexivity in grassroots. We need to ask ourselves: is this something they want, when for many, such discussions might feel like it slows down their process, is tedious? How can researchers create meaningful connections, give back, and make this process joyful for the participants?

ANNEXES

**ANNEX I: CRITICAL MAKING WITH AND FOR COMMUNITIES:
COMMUNITY-DRIVEN CRITICAL MAKING GROUNDED IN PRACTITIONERS'
PERSPECTIVES ON DEFINITION AND PRAXIS**

Critical Making with and for Communities

Community-Driven Critical Making Grounded in Practitioners' Perspectives on Definition and Praxis

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ABSTRACT

Critical making, a method particularly useful around “wicked problems” offers the chance to combine practices of making with critical thinking, to explore processes and topics utilizing technologies and materials and thereby learn or, in grassroots communities, create tangible artefacts which have a societal impact. Many of the growing number of makerspaces globally - though by far not the whole “global assemblage” of makers - foster participatory design for and with their communities to identify, highlight or solve local problems, explicitly or implicitly basing their practices on critical design. The term critical making is utilized in innovative scholarship, to describe design approaches, and DIY citizenship. During the 9th International Conference on Communities & Technologies, a workshop was organized by the authors to ground the term in grassroots innovation movements, with a special focus on the Global South, while recognizing the diversity and situatedness of making. Participatory methodologies were used to better understand the terminology of grassroots innovators, to discuss emerging and evolving issues of critical making, participatory design, and maker communities and to further develop the term critical making.

CCS CONCEPTS

• **Human-Centered Computing**; • **Collaborative Social Computing**; **Empirical studies in HCI**; • **Social and professional topics**;

KEYWORDS

Participatory Design, Grounded Design, Makerspaces, Connected Communities

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1 INTRODUCTION

The term critical making was developed as an approach to innovative scholarly practice, a method particularly useful to address and discuss “wicked problems” [Rittel et al. and Coyne as quoted in [27], p. 253] by using making to experiment and develop a collective frame that highlights and resolves disciplinary and epistemic differences [27].

“Critical Making is an elision of two typically disconnected modes of engagement in the world: critical thinking, often considered as abstract, explicit, linguistically based, internal and cognitively individualistic; and ‘making,’ typically understood as material, tacit, embodied, external and community-oriented.” [26].

In a book based on a collection of papers from an international conference in 2010, the term is redefined and explored to describe activities of DIY citizenship [29]. Critical making was later on adapted to help look beyond the idealized picture of the maker and to “reintroduce a sense of criticality back into post-2010 maker culture to un-sanitize, un-smooth and repoliticize it” [17].

In recent years, academic attention on Grassroots Innovation Movements (GIM) has been increasing, fueled by the “era of participation” [25]. Research has focused on the “global assemblage” [Ong and Collier 2004 in [22]] of hacker- and makerspaces as spaces of collaborative, collective or community-based design [3, 6] and grassroots innovation [32], with a focus on technological and sociopolitical analysis and the aim to highlight the diversity and situatedness of what constitutes as making [4, 22].

It is before this background that we asked ourselves whether critical making was a term that could describe the activities, processes and aims of grassroots innovation communities focusing on collaborative technology development in the Global South. Some practitioners explicitly refuse the maker label to describe their activities [7] as they feel like it describes a Western narrative of innovation [14, Csikszentmihalyi in [9]] and choose to use a Brazilian local word: *gambiarra*. Others, for example Indonesian practitioners prefer to focus on the co-creative processes of knowledge production and tinkering (*ngoprek*) rather than the ownership of a particular outcome [30]. *Jugaad*, the Indian term used can be translated as hack or resourcefulness, and *shanzhai* copyleft production practices in China are also getting more and more attention in an attempt to decolonize Western information technologies [4, 21].

The question arises: how many people engaged in making practices define themselves as makers, or even use the term making in the majority world? Building on this notion: how many grassroots innovators identify their practice with the term critical making, is this a term they might be interested in adopting? The authors have been aware of two references to GIM using the term: Fonseca's article on Gambiarra which refers to the term in a positive light [14], and a conference called Transformaking, inspired by Hertz's work and organized in the past by HONF Foundation¹ in Indonesia.

To unmask the utopian vision of making that is resting on technosolutionism and ideological colonialism and look beyond the maker hype and its promises [22], the authors of this paper decided to organize a participatory workshop and direct their attention to non-Western approaches like jugaad, gambiarra and ngoprek; as well as collectives and communities instead of makerspaces in order to unearth decades of critical making practices that have been labeled differently. The authors aimed to explore the possibility of further evolving the term, and to highlight locally relevant critiques of socio-political realities through grassroots technology innovation practices. This could help identify, analyze and understand the processes that are deemed too small and scattered, their relevance so hyper-local that they end up being overlooked by academia, while governments and traditional innovators such as corporations also do not invest into them. However, they contribute to valuable plurality and reflexivity [32] through their community-based knowledge production processes.

The hype and promises did not subside, in fact, since the workshop, the COVID-19 pandemic brought about a turning point in making: while governments and industries struggled with the breakdown of supply chains and the shortage of medical hardware supplies², maker communities designed, tested and produced necessary equipment locally and shared the blueprints globally [19]. While COVID-19 continues to act as a magnifying glass for wicked problems, making has not quite yet reached the democratizing potentials it promised, but maker communities have demonstrated innovative capabilities. This paper aims to show how maker communities, often under the radar of governments and industry, have been engaging in responsible practices and critical thinking, as well as open knowledge sharing, and it highlights the ongoing development of communities that make critically.

2 GROUNDING CRITICAL MAKING IN GRASSROOTS

To engage with practitioners, we decided to organize a one-day workshop. The 9th International Conference on Communities & Technologies provided a suitable platform for this workshop as it already aimed to broaden the spectrum of participants by reaching further than academia with the topic "Transforming Communities". The organizers developed questions and co-creative methods to explore how practitioners in the Global South engaged in critical

¹House of Natural Fiber: www.honf.org

²See e.g. the "Retas dari Rumah" hackathon in Indonesia focused on locally relevant social innovation through rapid prototyping <https://honf.org/tag/retasdarirumah/>, the Careables project, in which makerspaces in Brazil designed and produced PPE <https://www.careables.org/story/a-maker-lab-fighting-covid-19-in-brazil/> and online repositories for sharing blueprints and information were created <https://guides.library.unlv.edu/coronavirus/makerspaces>

making, including the audience of the conference and the vast networks of the Global Innovation Gathering³. In the call for participation, the organizers made sure to highlight an array of examples representing grassroots critical making In Brazil, Uganda or Indonesia, to inspire non-Western practitioners to join [32] and set out to explore the following three topics with the participants.

2.1 The Democratization of Innovation

One of the claims of the so-called maker movement is that making has the power to democratize innovation, by democratizing production and empowering the consumer [33] to make their own products through prosumerism, an imaginary "echoed (. . .) across the West" [Paltrinieri and Esposti 2013 quoted in [4]. While we share this vision in terms of (hyper)local knowledge production and appropriate technology design through access to tools and devices, we wanted to hear from the practitioners whether they thought the idea that making can make everyone an innovator applied to their practice and thus asked *Question 1: Does making democratize access to and practices of innovation?*

2.2 Extending the definition of Critical Making

The term critical making has been evolving from innovative scholarly practice [29], to DIY citizenship [28] and re-politicizing Western maker culture [17]. However, most of these definitions have been focusing on the West, Global North, or minority world, and few linkages have been explored between making activities, grassroots innovation and critical making in the Global South (see [14] or Transformaking conferences). The organizers hoped that the setting would leave enough room for the participants to express their discontent with the term. *Question 2: What is critical making for you?*

2.3 Inherent Criticality of Making

Making in and of itself is often anecdotally described by makers as a subversive and therefore critical practice, following the argument that opening the black box is criticality in itself, and ultimately enables everybody to make everything. Additionally, the storyline of many popular narratives of making - particularly in the Global South - is that the innovator in question utilizes making to solve a societal problem. In order to collectively explore the normative implications of the usage of criticality in these instances, we raised the circular *Question 3: Aren't all makers critical makers? Why should they be critical at all?*

3 CONFERENCE WORKSHOP AND ANALYSIS

In order to attract both academic and non-academic participants, the organizers shared a Call for Contributions on a dedicated website⁴ and via their networks of researchers, practitioners and activists: to ground the discussions in practice, the organizers explicitly encouraged participation from non-academic practitioners, ranging from global (with a special focus on the Global South) to local makerspaces in and near Vienna. Communities and practitioners were

³A global network of innovators, formally based in Berlin, Germany: <https://www.globalinnovationgathering.org>

⁴<https://criticalmaking.globalinnovationgathering.org>

asked to submit a position paper, a critical essay, piece of photojournalism, podcast, or video documentary on how the practitioners work is related to the workshop topic.

The workshop was designed as a one-day activity that would allow the organizers to create a common ground, give practitioners space to share their critical making activities, to co-create answers to the 3 questions above, and to allow participants to collaboratively design future projects.

3.1 Common ground

The workshop started with a keynote presentation from the organizers. The goal of this presentation was to share with participants research on the potentials and imaginaries of making [15, 23] and critique towards maker culture [2, 13], a brief overview of the state-of-the-art of critical making [8, 16–18, 26, 28, 29] and situating the term vis-a-vis related areas like critical technical practice [1, 10] or critical design [11, 12], in order to create a common ground for the rest of the day and ensure that participants had a shared basis of the term to build upon and decide whether current definitions resonate with them.

3.2 Case studies: Practitioners' Presentations

Aiming at getting a better understanding of what types of practices different people consider as critical making, the organizers invited participants to present their respective cases in the next part of the workshop. The format of the cases was deliberately left open to see whom it would resonate with, but with the precondition in the Call for Contributions that the selection would be made based on the contributions' relevance to the workshop themes, quality of submission and potential to stimulate discussion. This was necessary to ensure the goals of the workshop could be reached and because only a restricted number of participants could be hosted. 16 potential participants signed up for the workshop and 6 cases were selected for presentation. Three of these were impeded and could not share their cases, two because of a lack of funding, and another one because of visa issues. 3 out of a total of 10 participants presented their cases, with the other workshop participants sharing their experiences in group discussions and reflections. The presentations focused on shared commonalities such as: they were built around locally relevant and situated social issues, worked with their local communities to raise awareness, address these and/or co-develop a solution, demonstrated critical thinking skills in their practice, used tools and methods that resemble open-source community practices, and finally, worked in, with or inspired by practices in the Global South (see Table 1 Case Study Projects).

3.3 World Café Format for Co-Creation

Due to the limited amount of time and the aim to ensure that all participants could equally contribute, the organizers decided to use co-creation. In a world café there are different tables, each with its own host who is the patron of one question, which is written on the "tablecloth" - usually a piece of flipchart paper - of their table. All other participants are guests, who in groups first gather around one table. After some time to discuss the question and document their answers, the groups collectively move on to the next table. The host of that table briefly recaps the results of the previous discussion

and invites the new group of guests to add their thoughts. This format combines the benefits of small group interactions with a larger sample of participants [5].

3.3.1 Question 1: Does making democratize access to and practices of innovation? Dominant narratives and imaginaries of making claim that it makes innovation available to everyone: once people have access to tools, they become capable to innovate. Innovation in this case is understood in terms of market, meaning that a new product is created that can contribute to the growth of GDP, not in terms of e.g. responsible or social innovation. The organizers wanted to get the viewpoint of grassroots innovators on this claim and asked them whether they thought that maker practices made innovation more democratic through access to tools, skills and resources.

Analysis of the term innovation: The participants attempted to create a shared understanding of the word innovation. They agreed that it meant creating something new, but also addressed the process and the narrative around it: innovation is hard work, not magic, as some imaginaries of overnight successes in technology might suggest. Concern was expressed regarding the contextualization of the idea in order not to use it as "an excuse to hijack everybody into tech". As an attempt to separate commercial approaches from community-driven approaches, the participants differentiated social innovation, which they defined as reform, or socio-political disruption and innovation as a commercial term: "the latest (company name) product". The participants expressed strong emotions and critique towards the term innovation and its current perceptions. It was described as a buzzword they detest, one that is commodified, misused by capitalist systems and creating unnecessary competition. Referring back to the topic of the workshop, participants expressed that they believed critical making could now produce innovations as we understand them today, i.e. novel products or services that are market and profit driven, meaning that the goal of critical making lies somewhere else.

Innovation in maker practices: Discontent was expressed towards the status quo in making and innovation as such activities require a privileged position. What is often left out of the mainstream understanding and narrative of making is that being able to innovate requires accountability and transparency, but also access to information and infrastructure, such as electricity, internet and tools, which comes at a cost not everyone can afford. The participants asked for more tech literacy for all: education was deemed as ultimately what democratizes access and practice. The participants agreed that making has purposes other than innovation, it was about the process, yet they also recognized that making without tangible outcomes would be disappointing. The true purposes of making as an opportunity for education, developing skills like confidence, social skills and attitude, but also conflict resolution was mentioned, and to help people experience their ability to have impact. Participants associated values such as respect instead of judgement, empathy, and a safe space with the term making. The participants pointed out that intersectionality was necessary in making and innovation processes, including class, race, gender, nationality and caste.

When attempting to localize innovation in the maker movement, they chose a strong dichotomy and distinguished between bottom-up, grassroots hackerspaces and those that are financed or founded

Table 1: Case Study Projects

Project	Location	Social Issue	Community	Critical Thinking Skills	Tools and Methods
BeeCreative ⁵	Nepal	Hands-on application of critical thinking and making in the classroom	Students in schools as users, schools as stakeholders and partners	“A co-curricular program designed to bring stimulating hands-on experiences into the classroom. These experiences do not replace the regular curriculum, instead, they enhance it. (. . .) By getting students excited about (Science, Computing, OBT and Math), BeeCreative increases their willingness to learn in regular classes.”	A curriculum covering a wide range of topics, around which BeeCreative offers hands-on materials packaged as tailor-made kits, which they also presented as a case study in the Community Track Presentations of C&T2019
Mz* Baltazar’s Lab ⁶ [35]	Austria / Global	“A hackerspace for women and trans* individuals only!!”	Women and trans* individuals	“Generate resilience through commons” asking the question “how a space can invite people to cultivate creative practices and sharing without gender regime”	Workshops and exhibitions in which participants practice hacking as a feminist art practice; [virtual] global community-building; physical space in Vienna
The Bachchao Project ⁷ [34]	India	Building technology for diversity and inclusion	Women, LGBTQIA people and gender non-conforming groups, technologists and non-technologists	Community-centric efforts to develop and support open-source technologies and technical frameworks with the goals of mitigating gender-based violence and working towards equal rights for women, LGBTQIA people, and gender non-conforming groups	Research and advocacy; guiding communities in determining appropriate technological interventions for themselves; development of a set of guidelines for designing and improving technological platforms (web and mobile) in ways that make them utilitarian and friendly to a diverse group of users
<i>Disaster Relief Robots</i>	<i>Hungary</i>			<i>Not able to present</i>	
<i>LabCOCO</i>	<i>Brazil</i>			<i>Not able to present</i>	
<i>Making Sense Project and Citizen Data Lab</i>	<i>Spain</i>			<i>Not able to present</i>	
<i>Void Oracle Projects</i>	<i>Indonesia</i>			<i>Not able to present</i>	

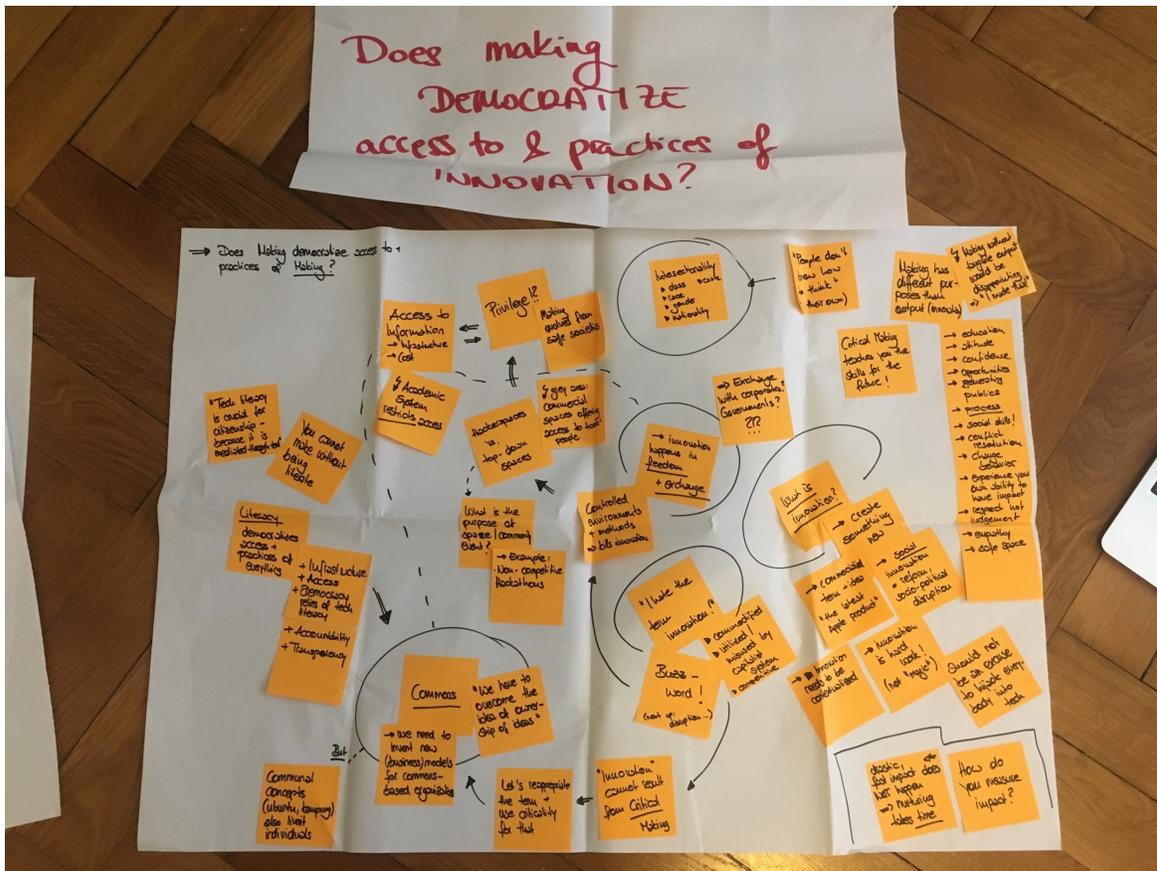


Figure 1: World Café Answers to Question 1. Photograph by authors.

in a top-down manner: they agreed that innovation happens in freedom from any political or financial influence and through exchange, e.g. through cooperative, collaborative methods. They raised the issue that controlled environments (government or corporate sponsored spaces) and controlled methods stifle innovation processes. They stressed the difference between hackerspaces and top-down spaces in terms of the purpose of the space and described a type of in-between, “gray area”, referring to commercial spaces offering access to tools.

Social innovation, open-source innovation and commons: Open source, commons and impact-driven innovation through making was a central thought. The participants expressed critique towards Western funding agencies’ approaches focusing on impact: criticizing that drastic, fast impact does not just happen overnight and nurturing social innovation takes time. The question of how impact can be measured in a helpful way was raised. To break the cycle of relying on external funding, the participants expressed the need to invent new (business) models for commons-based organisations, so that these can become financially sustainable while sharing concepts: “we have to overcome the idea of ownership of ideas!”

3.3.2 *Question 2: What is critical making for you?* Although the organizers had shared the state-of-the-art and current definitions

and practices of critical making, they were confident these ideas would not limit the participants when it came to reflecting on and grounding the concept in their own grassroots.

Frugal innovation: Participants associated critical making with the term frugal innovation, which is often used to describe bottom-up innovation practices with ad-hoc tools that solve local problems mainstream innovation does not have the interest in solving as the solution could rarely become profitable. Vis-à-vis profit-driven and exploitative innovation they mentioned the importance of meaningful impact and causing no harm, making “with focus and from the heart”.

Non-Western viewpoints and local contexts: The participants urged academia to observe critical making from a more nuanced, e.g. non-western perspective. From such a perspective contexts and communities are taken into account, where aside from practical making, processes of knowledge transfer and sharing stand in the foreground. Focusing on the purpose of critical making, they mentioned that bottom-up and top-down need to merge in a localized context, with an understanding of the use of local resources and know-how, as for example practiced by the Gathering of Open Science Hardware, GOSH⁸.

⁸<https://openhardware.science/>

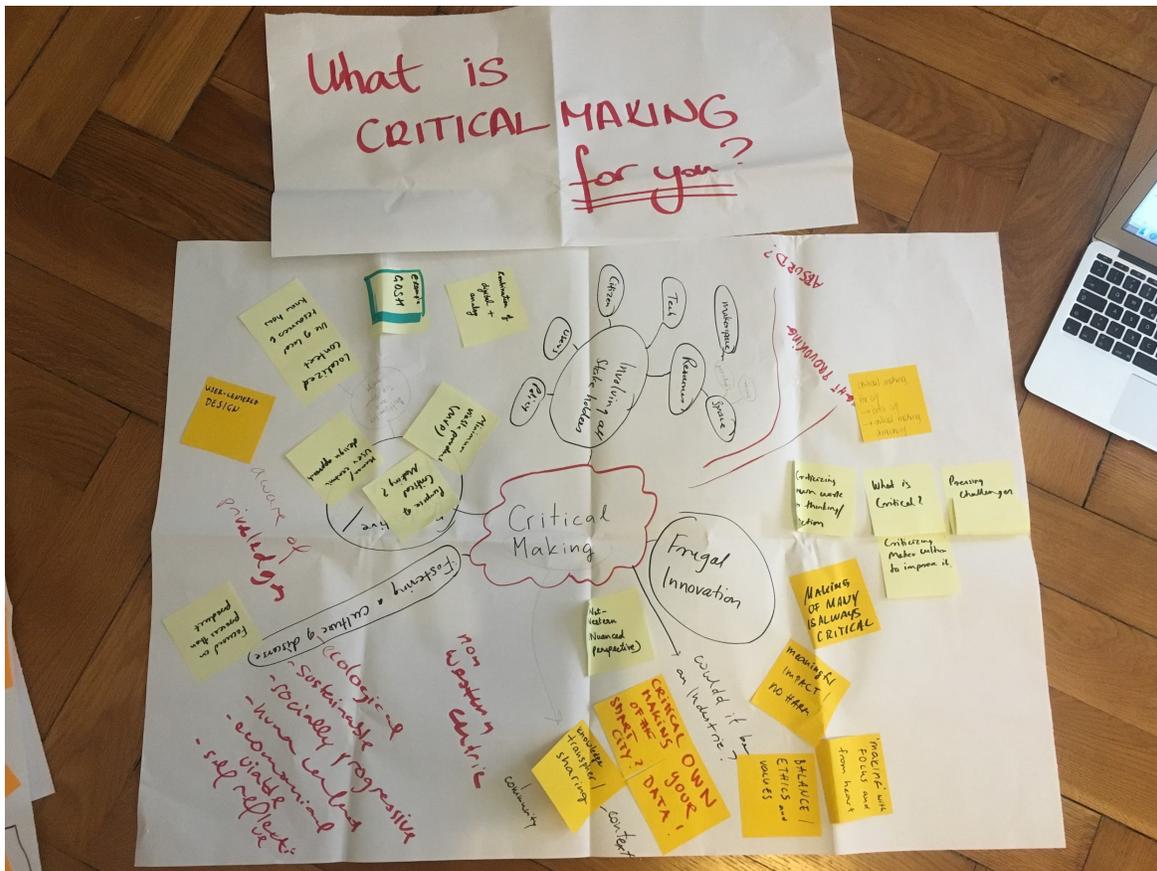


Figure 2: World Café Answers to Question 2. Photograph by authors.

A culture of discourse, reflection and responsibility: Critical making, in the opinion of the participants, fosters a culture of discourse. It is focused on process rather than the outcome or a product. This process is ecological, sustainable, socially progressive, human-centered, economically viable and self-reflexive. Critical making is thought provoking: it asks, what is critical? Does one criticize their own work, thinking or action? Does it criticize maker culture to improve it? Does it answer pressing challenges: is it democratic?

Ideas similar to those of responsible research and innovation (RRI) frameworks were mentioned, such as the importance of a balance of ethics and users owning their data. Participants also focused on the reflexive/self-reflexive process and highlighted that this needs to take place with a human/user-centric design approach. The process of critical making needs to be multidisciplinary and involve all potential stakeholders: policy makers, users, citizens and technology while critical makers need to be aware of the privileges they might hold.

3.3.3 *Question 3: Aren't all makers critical makers? Why should they be critical at all?* This final round asked a circular provocative question: Is criticality inherent in all making, as one of its aims is to open the black box that was designed to remain closed, or democratize technology so anyone can innovate and solve societal

problems? And why should makers be critical at all, when making could be seen a learning experience, a hobby, or could be a tool for entrepreneurship? The participants raised the following key points:

Making, critical making and ethics: Every product developed by makers that has impact needs to automatically require that the development process includes “critical analysis”. From the viewpoint of the participants, this distinguishes makers from critical makers: a maker is someone who finds a solution, while a critical maker is someone who doesn't stop there but continues working on the solution, meaning that service design takes place and people are integrated into the process. Participants raised the point that “the personal is political”. DIY being a grassroots activity, the DIY ethos cannot be institutionalized and thus inherently embodies empowerment and grassroots. If making requires reflexive methods and evaluating the work one does, this is something most practitioners instinctively do. The participants said it is imperative for makers to be ethical and to be aware of the status quo through its systematic analysis.

A community-based practice: Critical making requires a community: makers cannot be critical makers alone. The assumption was made that makers already know the context they work in, they are experts of their own contexts and thus, they do not reflect on

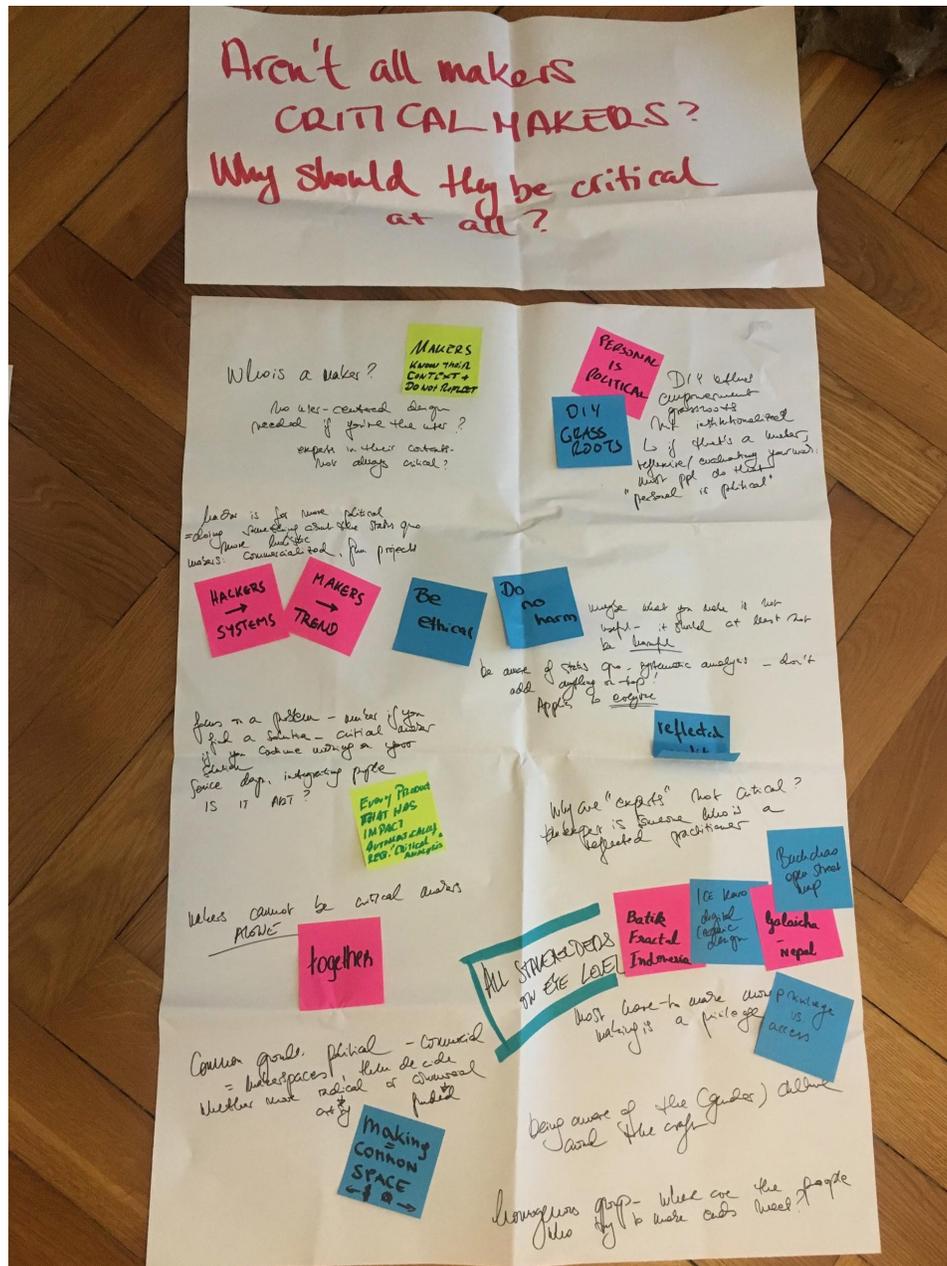


Figure 3: World Café Answers to Question 3. Photograph by authors.

situating their work. This assumption led the participants to a related question: is user-centered design needed, if you yourself are the user? Here, the participants mentioned the maker community’s dilemma: making happens in a common/shared space, where at some point the community needs to take a decision whether it gets political or commercial funding, or goes in a more anarchistic, radical, or arts-based direction.

Comparison with the hacker culture: Making was compared to hacking: the hacker is seen by the participants as someone who does more political work, i.e. who does something to change the

status quo and works more holistically. Makers seem to have their work commercialized or their projects are seen as “for fun”. While hackers change systems, makers today are representatives of a popular trend.

The question of diversity: The question of privilege and access was highlighted, pointing out that while most people have to make money to survive, learning about making and making as a hobby or activism is a privilege. The maker movement thus seems to be a homogenous group: where are the people who try to make ends meet? At the same time, as women have less time and disposable

income, gender is a major issue, thus being aware of the (gender) culture around the craft is crucial.

4 DISCUSSION

Although the time available for discussion was limited, the workshop had the advantage of engaging practitioners whose daily work is deeply embedded in critical making. Their presentations provided insights into emerging topics in critical making, such as: the importance of intersectional makerspaces, the need for guidelines of how to build technology for diversity and inclusion, or how making can enhance educational curricula. Grassroots practitioners interpret critical making through responsibility, ethics, and community-based approaches. Spaces in which people can safely express critical thoughts play a vital role in facilitating the emergence of critical making; be that makerspaces as localized physical spaces, or workshops as temporal spaces. The participants co-created such a safe space during the workshop through mutual appreciation, and explicitly wanting to learn from each other's successes but also failures without judgement.

Through discussions of the differences between critical making and social innovation, it became very clear that we need to move away from the Western understanding of making. The term critical making still cannot serve as an overall description of the activities, processes and aims of grassroots innovation communities focusing on collaborative technology development in the Global South, however, it proved to be useful in discussions between these members of the global assemblage of makers. While being aware of the shortcomings of any one term to summarize all different practices, critical making provided a framework both open and narrow enough to identify, discuss, share and better understand the different hyper-local, scattered processes which reflect the plurality and reflexivity of the global assemblage itself. The workshop participants shared a deeply critical outlook towards mainstream definitions, although the points of departure and experiences which brought them to that outlook varied greatly.

In the workshop, we could thus observe and simultaneously contribute to the politicizing of maker culture through the reintroduction of criticality, as Hertz phrased it in 2015, while it also served as a space for much-needed exchange between academics and Grassroots Innovation Movements (GIM) who together could further explore the diversity and situatedness of what constitutes as making.

Critical making was at an even more explorative stage in 2019 than it is now, and the workshop served as one opportunity to collaboratively explore it in depth and think out loud. This workshop as well as conversations with other participants of C&T2019 and Regina Sipos' ongoing research on Critical Technical Practice have led to the Critical Making project⁹.

Both bureaucratic and funding-related reasons remain essential as to why non-academic practitioners might not attend academic conferences. We consider the lack of representation and exchange with practitioners in the academic arena a shortcoming, which we along with many colleagues in academia, especially conference organizers, started to find creative solutions for - with much room for further improvement. We also reflect about how we as researchers

can give back to the communities we work with [20]. The Critical Making project involves practitioners and uses participatory action research and reflexive methods, including feedback loops. Dedicated funding is available to pay practitioners for their time and expertise.

The Covid-19 pandemic further affects how we evaluate the workshop in hindsight: back in 2019, we decided against blended online/offline participation, because we could not have guaranteed equity of participation in terms of cost and quality of connectivity as well as a good balance between physical and digital presence, which often negatively impacts the quality of exchange. With people being more used to remote tools, we would now stream the presentations, and possibly follow a remote-first approach with everybody participating online, even if they are in the same room. In the above-mentioned Critical Making project, we successfully conducted a first co-creation workshop with around 30 participants and open interaction with an online audience as a fully remote event.

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⁹<https://criticalmaking.eu>

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ANNEX 2: TOWARDS A CRITICAL MAKING RESPONSIBILITY FRAMEWORK: GIMxRRI MATRIX

		RRI Competence			
		Anticipation: Future-studies abilities Future-oriented ethical abilities Pro-activity Short explanation: Anticipation relates to the capability of forward-looking thinking: recognition of on-going and potential socio-economic and environmental changes and ability to be proactive and build the desired futures.	Reflexivity: Self-awareness Situational awareness Social awareness & empathy Ethical thinking Disruptive thinking Short explanation: Reflexivity refers to the ability to take a step back and consider ones actions from the critical distance: why did I act as I did and how my actions influence the surrounding community and physical environment.	Inclusiveness: Multi-perspective and inter-cultural communication Participatory ability Trans-disciplinary collaboration Openness & Transparency Short explanation: To be inclusive means to design innovation processes and activities so that they are open, accessible, safe and comfortable across different societal groups and allow all voices to be heard.	Responsiveness: Navigating complexity or wickedness Adaptability Agency Short explanation: Responsive innovation process acknowledges societal problems and aims to address them through available channels (in addition to RI may also include influencing standards, regulations & policies)
GIM	Context: social, historical, political, economic, cultural, religious contexts and other circumstances, issues and situations (=conditions), and windows of opportunities (see COVID-19 responses) that are available within the contexts that had a generative effect/impact that constrained the movement or project, could also include other relevant points like availability of resources or being resource-constrained	CONTEXT x ANTICIPATION Explanation: Ability to understand and act upon the on-going changes in social, historical, political, economic, cultural, religious contexts (trends & weak signals) and other circumstances and what kind of opportunities, restrictions and requirements they may provide in the future. Examples: -e.g. making from the industry's point of view, could be a sign of distributed manufacturing -so in making: community-based innovation processes that reflect upcoming societal changes (litmus test of societal change, kickstarting innovation, because innovative capabilities are based in community - we need proof for this, it's just a theory for now)	CONTEXT x REFLEXIVITY Explanation: To become aware of how social, historical, political, economic, cultural and religious context have affected on ones activities (innovations, projects etc.) and what kinds of contexts their reactions & innovations might create, (eg. vicious circles or hope, and for whom?) Example: Ensuring that visibility is acceptable for particular projects, e.g. the ones that tackle human rights issues in Indonesia; Grassroots innovators in Indonesia trying to help homeless people by developing water filtration tools, but as papers started reporting about them, these illegal settlements got evicted	CONTEXT x INCLUSIVENESS Explanation: To become aware of exclusive, contextual patterns - to understand that you don't by accident exclude others (like women, elderly, etc) - understanding how exclusion works and supporting people based on the contextual patterns of exclusion Example: NGO in Brazil: self-esteem and "time share" for participating in incubation programmes for underrepresented communities	CONTEXT x RESPONSIVENESS Explanation: To understand the particular societal needs arising from the context and to respond to them through making & innovations and in addition knowing "how to react and whom to contact to influence the societal rules of the game." Example: - Making & grass-roots innovations that directly address the needs of community are responsive. - If you have the networks - or can reach them e.g. local politicians to influence on higher levels - is a type of responsiveness)
	Framings: framings are "meaning production" mechanisms that help movements connect to powerful narratives, help express values and interests that mobilize and co-design the practice - beyond shared grievances and mere critique of mainstream practices (e.g. looking for solutions to change the status quo). It could include technological framings (open source) but also social, economic concerns (democratization through technological citizenship, sustainability in making). Reflexivity is important to analyze underlying assumptions, and it is useful to understand the inclusiveness/exclusiveness of framings. In a practical approach, problems, strategies, requirements, theories, knowledges, design criteria, exemplary artefacts, testing procedures and user practices that emerge through social interaction, solidarity, and coordinated action can be analyzed.	FRAMINGS x ANTICIPATION Explanation: To become aware of how used language and terminology shapes the taken actions and what kinds of values and interests are mobilized, maintained or challenged with the language used. Shared framings can help and hinder dialogues and once that is recognized, something new can be learned. Examples: e.g. open / source / innovation and how different members' experiences might clash in these wordings, leftist/socialist vs "capitalist" framing of social innovation (Indonesia vs Iraq), or e.g. when doing fundraising and framing the beneficiaries as passive, "in need of help", downplaying their abilities	FRAMINGS x REFLEXIVITY Explanation: To become aware of how chosen strategies influence other people or environment - what are the risks and rewards for the surrounding community and environment of the chosen strategies Examples: - e.g. what are the side effects of the strategies you have chosen? first you have to think about the strategy itself, because it might be something that was not deliberately planned (unintended/unplanned impacts you might have) - e.g. saying no to taking money from a big company - instead using limited but non-attached resources that would influence their values and practices in ways they deem as negative - they get machines from elsewhere for free - e.g. a 3D printer, so they start 3D printing and creating lots of plastic waste, instead of paper prototyping first (with cardboard etc) - an unintended impact of the resources they have	FRAMINGS x INCLUSIVENESS Explanation: To reflect upon and become aware of the wordings that are used, or the setup of the space, and whether they create inclusion or exclusion? Does the shared umbrella of interpretation lead to missing any perspectives? Examples: creating shared interpretations is a collective, discussion-based process. When someone brings something up, other things are downplayed: e.g. collective production of ideas and meanings - creates bonds but might also exclude others (does "maker" exclude "makeuses" and vice versa?)	FRAMINGS x RESPONSIVENESS Explanation: To explore how available resources will influence what you do (skills in the team; tools available) and how to act to expand them. Examples: - was there a case when they wanted to do something but their skills, tools, space, resource didn't let them - so they did it differently, how did that happen? the modification to still develop a solution? - change the space or using the resources available, has been learned how to do it (spaces for communication, action) - how was it possible?
	Spaces and strategies: what actions people take, and how these are influenced by the availability of resources, which could include spaces that are physical (makerspace and tools), social discursive (workshops and community discourses) or institutional (business and state interest?). In practice, we can analyze their locations and actions/activities that enable them to do experimentation and innovation differently, e.g. by enrolling audiences, alliances and users to improve their own performance (in a user-centred way, creating public engagement) and making alternative spaces of engagement, hereby mobilizing resources while considering the costs and benefits, risks and rewards of strategies, shaped by the conditions attached by resource holders that influence the outcome of their activities.	SPACES/STRATEGIES x ANTICIPATION Explanation: To become aware of ones own strategies to act, to learn to deliberately build strategies towards desired futures and to be able to anticipate what kinds of futures (and future spaces of action) the applied strategies create. Examples: -strategies are always forward-looking in itself, explicit or built-in/embedded idea of where to go and why -questions to make people aware of their strategies Potential questions: e.g. what is your goal for 2 years, 5 years? what kind of world do you want to see then and how does your project help you reach this?	SPACES/STRATEGIES x REFLEXIVITY Explanation: To become aware of one's own role and the situatedness of the activities carried out: how those impact/influence the environment. By recognizing the various pathways (anticipation), the potential social and ecological impacts can be reflect upon. Examples: If a community pushes for distributed manufacturing, they should recognize their own role in making the pathways happen: pathways that are more just, and the maker movement has contributed/can contribute to them in the future	SPACES/STRATEGIES x INCLUSIVENESS Explanation: To become aware of the norms and conventions that "made the space" of making & innovations: if excludes someone, become aware of these norms and conventions, physical structures and language. Examples: -cultural issues such as inappropriate for women to leave the home in the evening in Indo - so only men meet -need to become aware of what capabilities and skills are expected from people to be allowed to participate -obvious things like space accessible, tools accessible, website accessible...	SPACES/STRATEGIES x RESPONSIVENESS Explanation: To reflect upon whether the developed or imagined pathways maintain existing exclusive structures, do they create new exclusions, new divisions between people? How can they be made more inclusive? Examples: Activist lobbying for internet laws in Indonesia to be more open in the late 1990s; enabling remote communities today to have their own community network without being hindered by complicated laws.
Pathways: the plurality of alternative pathways and potential impacts (there is not just one self-evidently best pathway, and the political nature of grassroots movements might contribute to new pathways created with greater attention to issues of social inclusion, diversity and difference and social justice). How did/do/will they contribute to alternative development over time? Practically, one could analyze the fate and influence of ideas and aims (which ones are shared and picked up and why, which ones did not resonate and why?); how do the movements develop and respond to changes over time? how does this influence their pathways? Materiality of objects (artefacts) and practices can play key roles in this analysis.	PATHWAYS x ANTICIPATION Explanation: To become more aware of what sort of pathways are supported: what future pathways are made while doing concrete projects, and reflect upon the potential plurality of it, to anticipate the impact of the ethical pathways. To recognize the path dependencies, become aware of what one can change with the created pathway and what not. Examples: One might only be able to make efficient change when other prerequisites are achieved, e.g. change is blocked by existing structures, but with long-term planning of a pathway, one can have an impact. Envisioning can help: what's the future you're aiming at, what are the different pathways to get there?	PATHWAYS x REFLEXIVITY Explanation: To become aware of one's own role and the situatedness of the activities carried out: how those impact/influence the environment. By recognizing the various pathways (anticipation), the potential social and ecological impacts can be reflect upon. Examples: If a community pushes for distributed manufacturing, they should recognize their own role in making the pathways happen: pathways that are more just, and the maker movement has contributed/can contribute to them in the future	PATHWAYS x INCLUSIVENESS Explanation: To reflect upon whether the developed or imagined pathways maintain existing exclusive structures, do they create new exclusions, new divisions between people? How can they be made more inclusive? Examples: Activist lobbying for internet laws in Indonesia to be more open in the late 1990s; enabling remote communities today to have their own community network without being hindered by complicated laws.	PATHWAYS x RESPONSIVENESS	

ANNEX 3: CASE ACTION CO-DESIGN WORKSHOPS

Working With Grassroots

As this project is developed by an interdisciplinary team which includes researchers, but also people working with grassroots innovators and practitioners, the project has been built on access to and experience working with grassroots. Access to this diverse “global assemblage” of grassroots innovation movements is thus not an issue. However, as outlined earlier, critical making is not a term that grassroots innovators are necessarily aware of or identify their practice as; in fact, even making is a term that some are not familiar with. In addition to the terminology, the innovations done in grassroots is done under the radar of academia, in a scattered, local, and periodic manner, the infrastructuring processes of “naturally” developing grassroots projects (without any intervention from academia) thus remains difficult to access. Researchers need to be careful because power imbalances can cause issues, and meddling in grassroots activities is seen as problematic by many grassroots innovators (e.g. that the researchers only “take” from them while they deliver unpaid work). The project promises to assess and improve reflexivity in grassroots, but is this something they want, when for many, such discussions feels like it slows their process down, is tedious?

This project is thus an opportunity for researchers also to learn about reflexive methods and try these out on the ground, but also to develop ways to “give back”. In addition to the reflexive-participatory methods above, and learning from other researchers, the project also invited practitioners to share their insights at the co-design workshop. They were asked to share best, and worst practices of how different maker projects teach or transfer skills of e.g. critical thinking, reflexivity, support openness or gender inclusion. As the workshops had to take place online, input was documented on a collaborative digital board, screenshots of which help create an overview of the information shared. Discussions with case actions and relevant inspiration is shared below.

Case Action: GENDER

The starting point for this workshop was that the maker movement (as many technology-based disciplines) is male dominated. The WP leads asked which mechanisms, strategies, spaces are out there to make the movement more equal and more gender inclusive? In addition to the consortium members, 8 practitioners from around the world joined the

1,5-hour workshop and shared 32 programs/projects, 37 spaces/communities and 24 online role models.



Figure A3.1 Outcomes of the Gender Co-Design Workshop

The participants first asked what exactly is meant by spaces: how is making framed? Practices are different depending on the context: is it a hobby for school children, activities for tech student, engaging women in tech professions, a social approach? Often makerspaces are understood as physical spaces, but the focus is increasingly on communities (platform), e.g. in Brazil it is not mainly about access to machines: exclusive spaces just for women, and in addition to gender, also inclusive in terms of race and other aspects. It is costly and difficult to build nice makerspaces, the focus is on the contents offered rather than on physical spaces with expensive machines. Others shared that they have spaces, but it is important that it is not only one room but a community.

While collecting inspiring cases, in terms of research about practitioners in the case actions, participants stressed the need to be reflexive. It was highlighted that there was a “danger that the list starts to represent the reality”, it should thus be evolving as grassroots evolve. There is also a problem that spaces are exhausted and colonized, as many researchers are contacting them doing research, which may also hamper their activities. The responsible researcher needs to be aware of the risks caused by research activities to the “research objects”. Important to discuss with the people engaged in research initiatives to ask about what they need, how we can give back instead of just exploiting.

As next steps, the most important needs to improve diversity in making mentioned were role models, facilitators (peers & the ones who help), skills, and topics that are engaging for girls. In terms of research, the advice was given that instead of looking at all the initiatives and try to search for common patterns, rather to go into detail into some of them to understand the particularities and diversity.

Based on the input received in the workshop, the researchers started interviewing potential communities to co-develop projects with. These include a hackathon for girls in India, that will inspire them to become entrepreneurs in the future, digital and remote

STEM education for girls in South Sudan, where access to computers is rare and electricity is not reliable, but content could be shared via podcasts on SD cards. Early mock-ups should be further developed through things that already exist. Discussions were held about how the researchers can also build more reflexivity into this for themselves, but also for the participants: how can they engage in criticality, reflection, responsibility. Points raised in the workshop, e.g. that participants and beneficiaries are not mere “empty vessels waiting for the innovation”. The developed solutions also need to be sustained, it is important not just to leave something behind, and take from the beneficiaries. Based on the input from reflexive practitioners, there is a need for internal reflection about what do we build into our own processes and how? E.g., how does our gender or Western perspective influence our own research?

Case Action: **YOUNG TALENTS**

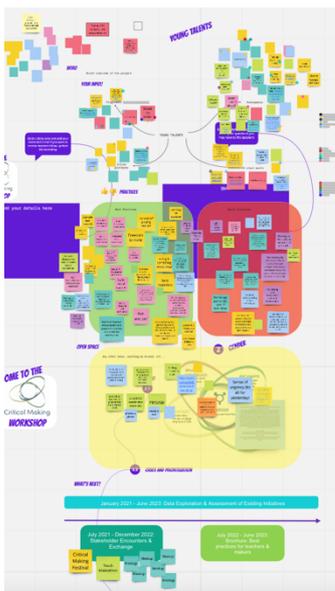


Figure A3.2 Outcomes of the Young Talents Co-Design Workshop

In this workshop, the consortium members were joined by 8 practitioners from around the world. The starting point for the discussion was that in terms of education, making has become a buzzword that is related to certain attitudes, and activities where making is just for the purpose of making something. The participants highlighted that since the pandemic, blended maker spaces combining physical and virtual/offline and online maker spaces have become very relevant. They shared 9 programmes, 11 online platforms, 30 makerspaces and 9 educational models, and highlighted as most important, innovative aspects challenge-oriented work, a careful concept of inclusion (e.g. after school day activities engage children from higher education families), attention on code of conduct to protect children’s rights. Art education makerspaces in museums were mentioned that

act as content pools. Spaces for practicing afro-religion was mentioned and spaces focusing on collective memory and diversity, involving people of colour.

In terms of best practices, it was mentioned that attention needs to be paid on wording (the word maker has a male connotation in many languages), and practices, where making is an invitation to share with others and “shop around” from other projects to building upon work of others: sharing, not competitive practice.

In terms of worst practices, or mistakes to avoid, it was mentioned that Critical Making should pay attention to the premises behind the tools chosen (e.g. open source tools vs. Microsoft, Google etc.). There should always be a discussion on the openness/closedness of the tools chosen. Proprietary tools can be used but then an open discussion is necessary why the choice is made. It is important to inspire people to ask questions about ownership or embedded sustainability issues of tools.

Issues around sustainability and making practice that addresses to climate crisis were discussed: for example educational toy boxes are often ordered from China. There is a need to become aware of and discuss such environmental questions: how to create tools and devices that are sustainable as such, fair electronics, the opportunity to reuse electronics: fair production, reusability is what makes making responsible. Projects that promote autonomy and contribute to solving the climate crisis and promoting inclusiveness are to be encouraged - making could and should be a wonderful tool for education and empowerment.

In terms of next steps, in this first phase, research is done on educational maker activities in Berlin and in Germany, in order not to lose focus. While maker education can learn from workshops organized by Ratto, Hertz, or e.g. critical engineering workshops by Balogh, there are also examples to get inspired from that are in Germany (Hacking Innovation Bias at the TUB), however, these are all higher education curricula. It is also a question how we define critical making for education: is it about fostering reflexivity, critical thinking, or help express criticality towards something and spark conversations? How is making utilized to support learning and thought processes, is failing allowed?

Case Action: OPENNESS

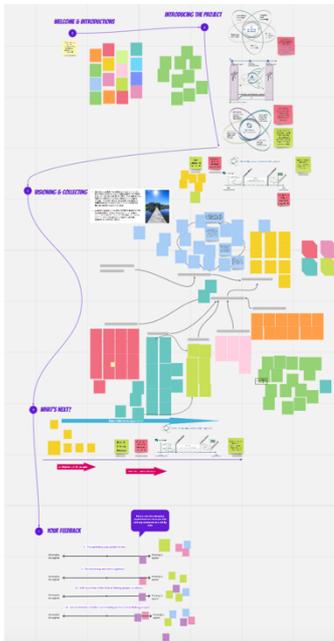


Figure A3.5 Outcomes of the Openness Co-Design Workshop

This workshop was supported by VTT in its methodology about how to co-design the open hardware program. It started with questions such as

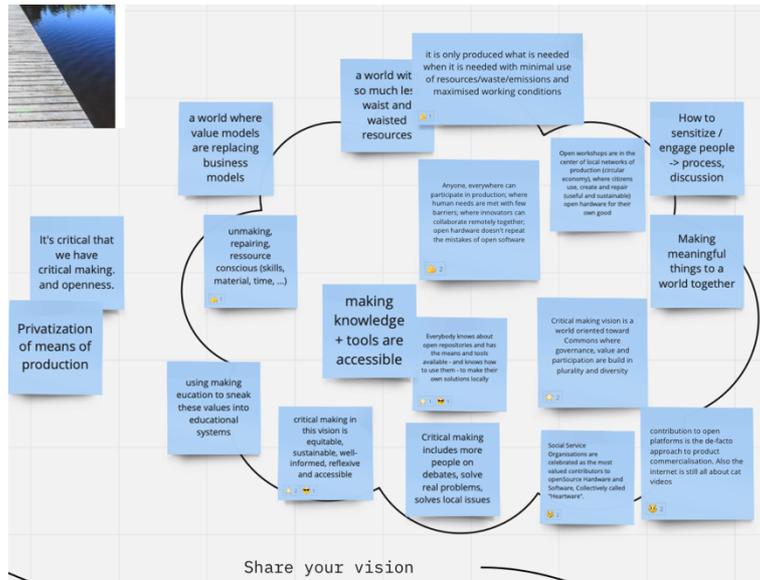


Figure A3.4 Visions of Open and Critical Making

“what does a world look like in which all making is critical and open?”

The 9 invited practitioners shared best practices to learn from: 17 bad examples, 18 good examples, 8 online platforms, 7 standards of OSH, and 10 cases of OSH making business models. Values in openness that were highlighted included oriented towards commons, value and participation, value models rather than business models, producing less waste, focus on unmaking rather than on always making something new, community realities (critical making includes more people in debates), solves real problems. The focus on local networks where you can use tools on a local level, while open hardware is important in local production networks (circular economy). The participants highlighted the importance to engage people in making: so they understand how technologies are made and then discuss the embeddedness of technologies, to provide access through making for people who do not have any connection to that practice.

Regarding the connection between openness and criticality, what makes making critical was discussed: it is a political statement, being critical means that underlying power structures are recognised. It includes two layers, the first one is a vision, the second one

is the practices that make the vision possible. *Plurality and diversity are at the centre of the vision of openness*. There is a need to be aware of things that are branded as critical without any criticality, important not to just make things but simultaneously enhance reflexivity and to pose questions about where things come from, are they responsible, accessible, sustainable, to be aware of technologies and circumstances that *make things not open for people*.

Open source knowledge practices can help us in learn more about well-functioning open hardware practices, it is thus a learning process for everyone involved.

Mainstream and “trendy” things are dangerous because they hide the alternatives. Looking at alternatives shows new structures and infrastructures and allows engaging more diverse people. E.g. the fashion of big data fashion undermines the value of local datasets (small data, meaningful data) and alternative approaches. This applies to communities too, the book *Making Massive Small Change* was mentioned (Campbell 2018) as an example on how to make small local communities in big cities.

Based on the input received during the workshop and 3 subsequent exploratory interviews, the researchers identified the question of how criticality can be included into the work package. Openness and criticality are highly situated and depend on access, there are differences between the practitioners’ starting points and ways of thinking. Whether it is a question of tools (how to document reproducibly, where to share the blueprints) or methods (e.g. sharing openly and non-competitive hackathons), remains a question to be explored. These questions also inform the design of the pilot incubator: What does openness mean for criticality when most blueprints are not useable for reproduction? If people want to share openly, how does that need to happen and what would make it really *open*? Grassroots movements have different issues with access, these need to be explored: through the perspective of someone in a makerspace who wants to make something; and ask questions such as “who thinks about standards where there are no standard systems/IP rights where they are?” or “Why would someone engage in openness when they are not getting paid for it?”. These are some first questions that arise that influence how the incubator needs to be shaped.

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