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Towards a critical technical practice in disaster risk management: Lessons from designing collaboration events

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Towards a critical technical practice in disaster risk management: Lessons from designing collaboration initiatives

Authors

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Abstract

The technical expertise of the engineering discipline is a dominant input into the information systems and products shaping our knowledge of disaster and climate-change crises. Despite decades of social science research into disasters, policy and practice in the field continues to be informed largely from a technical and data driven perspective. The outcome is often a perpetuation--and sometimes deepening--of vulnerability, as narrowly defined technical interventions fail to address or recognise the ethical, historical, political, institutional and structural complexities of real-world community vulnerability and its causes. We propose that addressing this does not require a rejection of technical practice, but its evolution into a *critical technical practice* - one which foregrounds principles of interdisciplinarity, inclusion, creativity and reflexivity, as a means to question the assumptions, ideologies and delimited solutions built into the technical tools for understanding risks. We present findings from three events we designed and facilitated, aimed at rethinking the engineering pedagogy and technical practice of disaster risk management. The first was a 2-day "artathon" that brought together engineers, artists and scientists to collaborate on new works of art based on disaster and climate data. The second was the Understanding Risk Field Lab, a 1-month long arts and technology un-conference exploring critical design practices, collaborative technology production, hacking and art to address complex issues of urban flooding. The third was a 4-months long virtual workshop on Responsible Engineering, Science and Technology for Disaster Risk Management. Each of these events uncovered and highlighted the benefits of interdisciplinary collaboration and reflexivity in disaster risk modeling, communication and management. We conclude with a discussion of the key design elements that help promote the principles of a critical technical practice.

Contents

Introduction

Disasters affect millions of people every year, leading to loss of livelihood, forced migration, injury and death. Mounting evidence suggests that global risk is increasing due to a combination of climate change, patterns of urbanization, and ongoing or deepening economic and social vulnerabilities (Fraser et al., 2016; World Bank, 2021). To understand, quantify and manage disaster risk and impacts, experts from a number of scientific and engineering disciplines produce information products such as risk models, hazard maps, or post-disaster damage assessments. These tools have provided a powerful new understanding of climate and disaster risks. However, the field has come under increasing criticism for valuing engineering, natural sciences, and other "technical" fields over other disciplines and ways of knowing (Muller, 2000; Tsing, 2012).

The emphasis on technical fields has encouraged the recasting of complex social-environmental issues of disaster and climate risk into structured, clear and technical problems that can be computed and solved. Such technical solutionism fails to address the intrinsic complexity and ambiguity of climate and disaster risk (*Reghezza-Zitt & Rufat, 2019;* Morozov, 2013). Further critiques have pointed to the Disaster Risk Management (DRM) field's failure to adequately incorporate the perspectives of stakeholders and at-risk communities (Meng et al., 2019; Wobbrock & Kientz, 2016), and its tendency to reinforce unequal power relations between people or countries (Gaillard et al., 2019; Soden & Kauffman, 2019). As with a number of other fields that engage with pressing societal issues, people are raising urgent questions about the information systems and disciplinary lens that frame our understanding of these issues and inform how we respond to them (Benjamin, 2019; Costanza-Chock, 2020; D'Ignazio & Klein, 2020).

Computational approaches to assessing disaster risks and impacts are increasingly sophisticated, involving hazard, risk and structural reliability analysis, remote-sensing and mapping, cost-benefit analysis and engineering design. These provide a deeper understanding of risk but also contribute to increased specialization in the field and privilege some perspectives over others. Indeed the technical expertise of the engineering discipline (i.e. hazard, risk and reliability analysis, software development, GIS) is a dominant input into the information systems and products shaping our knowledge of disaster and climate-change crises.

Despite decades of social science research into disasters, the current policy and practice of disaster risk management continues to be informed largely from this perspective. The shifts to incorporate vulnerability, and more recently resilience, into DRM practice, although acknowledging the social production of risk, have not led to a paradigmatic change in practice. In fact, "the promotion of the resilience / adaptation combination tends to paradoxically reinforce the 'technicizing' of action plans" (Reghezza-Zitt & Rufat, 2019). The outcome is often a perpetuation--and sometimes deepening--of vulnerability, as narrowly defined technical information systems fail to recognise the social, historical, political, institutional and structural complexities of real-world community vulnerability and its causes (Coetzee et al., 2019; Ford et al., 2016; Older, 2019). As an illustration, the probabilistic risk analysis framework which emerged originally to ensure the safe design of nuclear power-plants (USNRC, 1983) is now used to calculate the potential impacts of floods on coastal communities for different recurrence-interval events. Calculating impacts in terms of monetary loss enables this information to be integrated into cost-benefit analysis used to leverage

investments in coastal protection infrastructure. Yet one outcome of this approach is a systematic protection of areas with high property value over areas with lower property values, rather than prioritizing protection based on vulnerability to flooding. In other words, cost-benefit analysis in disaster risk management often silences those with small potential losses not because they are not vulnerable, but because they have low-value assets (e.g. informal communities).

We propose that addressing this does not require a rejection of technical practice or technical disciplines, but rather its evolution into a *critical technical practice* - one which foregrounds questioning the assumptions, ideologies and delimited solutions built into tools understood to be merely technical (Agre, 1997). Following Boehner et al., 2005, we define a critical technical practice as one that "binds technology development [...] with critical reflection (as practiced in critical studies and design research), thereby uncovering and altering hidden values and assumptions in technology design". It will also require much deeper and more egalitarian collaborations across disciplines, and with at-risk communities. In this paper, we discuss some of the key design principles needed to support a rethinking of technical practice in disaster risk management (Section 2.). We then present findings from three events our team designed and facilitated, aimed at rethinking the process of technical practice of DRM (Section 3.). Recognising that the translation of abstract principles into tangible design elements is context and needs-specific, we chose the three case-studies to cover a breadth of contexts and event types. The discussion (Section 4.) brings together the key design elements that facilitated the achievement of the critical technical practice principles. While we do not provide a complete framework for the implementation of critical technical practice design principles in DRM, this work instead provides examples and points of reference.

Rethinking technical practice in disaster risk management

The last decade has seen the multiplication of innovation awards, collaboration funds and networking events (e.g. conferences, workshops, hackathons) in the DRM sector. Modelled after the tech industry's approach to innovation, and often focused on tech solutions, these are seen as relatively inexpensive ways to generate ideas, form new collaborations and develop products addressing disaster risk management issues. Yet they raise questions about who are the voices participating, and what are the disciplines and types of knowledge being prioritized in these activities. Critiques have also highlighted the focus on technical solutionism in disaster management (Gaillard et al., 2019), suggesting novel design principles for promoting a more critical and inclusive technical practice in DRM. We identify a series of **design principles** to promote critical technical practice in DRM.

Egalitarian interdisciplinarity

Egalitarian interdisciplinarity ensures that people and approaches from different disciplines are given equal weight, and not merely used in support of technical solutions. The field of climate and disaster risk management grapples with difficult challenges at the intersection of human and natural systems. In possible response to this, the fields of climate and disaster risk management have frequently positioned interdisciplinary research and practice as a solution for addressing the issues and uncertainties that characterize complex social-environmental systems (Cross & Societies, 2018; Orlikowski & Yates, 2002; Sengers et al., 2005). The intersection of multiple perspectives that interdisciplinary work entails offers to

bring greater understanding of the social aspects of these issues. Interdisciplinary approaches are also seen as necessary due to the many different kinds of research relevant to issues of climate change and disaster. In addition, scholars have highlighted the potential for interdisciplinary work to go beyond instrumental aims of solving problems, to perhaps more important aims of shifting perspective and rethinking ways in which problems themselves are framed (Kogan et al., 2020; Soden et al. 2021). Recognizing the benefits of interdisciplinary thinking and multiple kinds of knowledge means designing for egalitarian collaboration across disciplines. This goes beyond bringing people and disciplines together, and entails equalizing partnerships across disciplines so that non-technical fields are not simply used in service of technical solutionism.

Inclusivity

The climate and disaster risk management field has been criticised for reinforcing unequal power relations between people or countries, and failing to adequately incorporate the diverse spectrum of stakeholders of risk reduction interventions (Meng et al., 2019; Wobbrock & Kientz, 2016). Beyond the goal of interdisciplinarity, there is a need to consider more diverse ways of knowing (Ford et al., 2016), which are not necessarily formalized in academic scholarship. Such inclusive approaches are important to consider different voices. Disaster risk practitioners have their own cultural biases, sometimes termed WEIRD (Western, educated, industrialised, rich and democratic), failing to recognize the diversity of needs or aspirations from the majority of the populations they aim to support (Henrich et al., 2010).

Creativity

The challenges and limitations of current DRM practice call for novel ways to engage, analyze, and implement risk reduction measures. One of the key goals of critical technical practice is to acknowledge and work past the delimited solution space created by narrow and siloed approaches to problems. Art-science collaborations, speculative fiction, and other creative design methods are increasingly being used to support climate risk understanding and communication (Lehmann & Gaskins, 2019; Scheffer et al., 2017). Another important factor to the development of novel and creative approaches to DRM is access to resources for very early-stage thinking. In general, opportunities to fund well-developed and presented ideas exist through universities or calls for projects from philanthropic or development aid organizations. However, few opportunities and space are given for the *process* of developing ideas and *forming* effective collaboration. Proposal requirements for "collaboration" will often be treated as a check-box, adding partners to an existing proposal rather than true ideation and co-creation with equal partners.

Access to resources for early-stage ideation between non-traditional collaborators can promote creativity. This can be financial resources or information, for example promoting networking among actors from academic and local governments (e.g. the EPIC network, https://www.epicn.org/).

Reflexivity

Both prior and following innovation in DRM, there is a need for a reflexive process aiming at discovering successes and challenges from practice. For communities of practice, this reflexive process may take place at professional events like scientific conferences, more inclusive events and workshops, or through participatory or human-centered design events. For individuals, this process may be fostered by conversations with collaborators and stakeholders working on a project, as well as personal practices such as journaling, reading, etc. The concept of critical technical practice (Agre, 1997) illustrates this principle by promoting reflexivity on individual professional practices. By scrutinizing key assumptions and mental models taken for granted in a field, such practices aim to improve the societal impact of technical fields.

To put these principles into practice, we created three events aimed to facilitate the development of responsible and socially engaged collaboration on climate and disaster risk management. The first was a 2-day "artathon" that brought together engineers, artists and scientists to collaborate on new works of art based on disaster and climate data. The second was the Understanding Risk Field Lab, a 1-month long arts and technology "un-conference" exploring critical design practices, collaborative technology production, rapid prototyping and art to address complex issues of urban flooding. The third was a 4-months long virtual workshop on Responsible Engineering, Science and Technology for Disaster Risk Management. Each of these events uncovered and highlighted the benefits of cross-disciplinary collaboration and reflexivity in disaster risk modeling, communication and management. We present these as case studies and examples (imperfect ones) for the design of multi-disciplinary collaboration in DRM, with a focus on key design elements meant to address some of the concerns highlighted earlier.

Case studies

Artathon

Description

The first case study is the artathon, a two day event held in April 2017 that brought together approximately 30 artists, engineers and scientists to create new works of art that engage with questions of climate change and disaster. Held in San Francisco, the artathon focused on issues faced in the region related to hazards such wildfires, sea level rise, flooding, and earthquakes. The San Francisco Bay Area is home to numerous artists engaging with social and environmental questions and local government, non-profits, private sector, and research institutions actively engaged in addressing disaster risk management challenges, making it an ideal setting for an art and science collaborative event focused on these issues.

The group, which consisted of academics, professionals, and working artists, was led through a series of exercises to introduce them to the concepts, questions, and data before beginning work on their art projects in assigned teams of three or four.

The event was a two day sprint with a focus on production of work. The final outputs varied in focus, medium, and stages of completion, and were exhibited at an art gallery in the month following the event (Figure 1).

The majority of the first day was dedicated to structured activities before opening up to a freeform event. The event began with a series of activities aimed at establishing and sharing

individual expertise and familiarising participants with each other, with the physical space (pop-up collaborative space for earthquake policy research and development), material resources (art and fabrication supplies), and digital resources compiled by the organizers (statistical and geospatial datasets on regional hazards).

Teams were then formed and led through a number of design-thinking workshops aimed at rapid ideation around the mediums, hazards, and themes that their projects might engage with as part of a brainstorming phase. The second day was completely open and focused on production. An external facilitator led a feedback session to help the participants reflect on the event and provide feedback to inform future events. Following the artathon, some teams continued to collaborate to further the pieces before the exhibitions at an art gallery in San Francisco and Stanford University campus. The opening events at each exhibition were another opportunity for participants to gather, reconnect, and share their work and experience with a broader audience.

Outputs and Outcomes

Each team produced at least one piece for inclusion in the exhibitions, each at varying stages of completeness. It is not possible to do justice to the outputs from the event in this paper (see Soden et al., 2020 for details), however a summary is provided here:

- *Ironic Advertising Posters:* the "aim of this work was to take sea-level rise forecasts for iconic areas and use irony and humor to inspire the public to action";

- *The Bellwether Tree* was "a proposal for a large-format sculpture, featuring a cross-section of a redwood tree... [that] tells the story of human's entanglements with the environment through the width and shape of its rings";

- *Coastal Resiliency in a Changing Climate:* a "game centered around a hanging mobile with several tiers, each of which represented certain decisions and tradeoffs such as potential tension between developing new housing and preserving land for biodiversity."

- *Lights on Climate Change:* "an audio-video project that raises the question of voice in the discourse surrounding climate change", weaving together audio from interviews with artathon participants to create a polyphonic audio track that was played over visuals of lights on a world map highlighting where participants had lived and worked.

- *Process Reflections:* a collection of pieces illustrating "their process over the course of the artathon, sharing their design notebooks, sketches, paintings, and handwritten text containing personal reflections on risk and resilience"

- *Submerge: Emerge:* "several mockups and a clay model of a rammed-earth constructed maze with blue plastic water bottles forming the interior walls"

- *Invisible Dialogues:* "The installation places one existing tool for earthquake measurement, a seismograph, alongside two speculative technologies that measure things such as our impact on the world around us, and how our desires draw us through the world, helping us gauge which types of desires have the strongest pull."

Figure 1. Selected process and output images from the artathon. (a) the Bellwether Tree, (b) Ironic Advertising Posters, (c)-(d) Process Reflections, (e) Lights on Climate Change, (f) Submerge: Emerge, (g)-(h) digital and data resourcing activities, (i) exhibition at art gallery.

Understanding Risk Field Lab

Description

To expand on the artathon concept, Co-Risk Labs designed a month-long event, the Understanding Risk (UR) Field Lab in Chiang Mai, which fostered interdisciplinary and participant-led explorations on the topic of urban flooding.

Throughout the four-week event more than 150 engineers, social scientists, designers, cartographers, researchers, non-profit staff, government officials, and citizens worked together to connect and expand the many approaches to flood risk management. The product-oriented event brought together local and international experts to explore this topic through a fluid timeframe and emergent schedule. Participants were selected based on their application material and represented many disciplines within DRM, and many nationalities.

The event took place in Chiang Mai, a medium sized, flood-prone city in Northern Thailand. Chiang Mai was chosen as an ideal site for several reasons: (i) it experiences regular urban and riverine floods, (ii) it has a well documented history of both ancient and modern flood management interventions, (iii) it is emblematic of rapidly urbanizing secondary cities, (iv) it has very active civil-society organizations and high-quality universities, (v) it is an easily accessible and affordable hub to host participants from the region, (vi) it is one of Thailand's designated "smart cities," yet it remains a culturally and historically rich destination.

Figure 2. The flexible schedule, referred to as "The Board", and the UR Field Lab site (International Sustainable Development Studies InstituteISDSI).
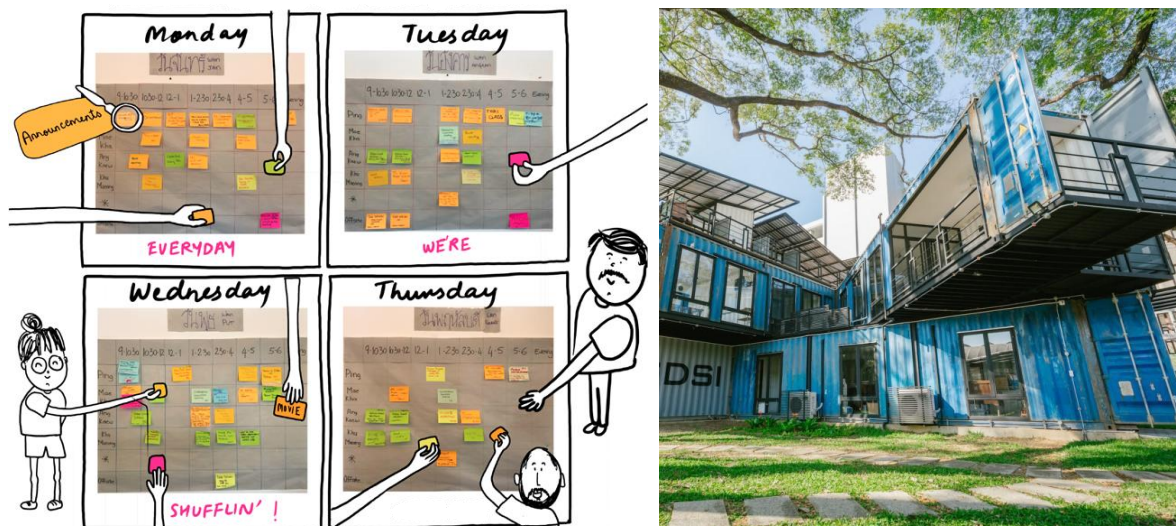
The location and the facilities were an integral aspect of the event design. The event was held at the International Sustainable Development Studies Institute, which is located conveniently near the center of Chiang Mai City. The spatial and aesthetic design of the institute, built out of repurposed shipping containers, provided creative inspiration, and the site, which is normally used to host international students for study abroad activities, supported the emergent nature of the event. Within the space, one large wall became "the board" (Figure 2), the key organizing tool throughout the month. The board started as a blank calendar each Monday and was filled in with sticky notes as participants self-organized meetings throughout the week, a key aspect of Open Space Technology (see Discussion section).

Each day started at 9am with announcements, and the rest of the day was divided into 1.5 hour increments, ending at 5pm. There was an end of the week wrap up during the last hour on Fridays. Participants were encouraged to spend time relaxing or exploring Chiang Mai in the evenings, and some excursions planned throughout the event, which provided many opportunities for informal interactions.

Altogether, the location and facilities accommodated various working styles and personal needs throughout the event and allowed participants to work together and relax together throughout their time at the event, building lasting partnerships for future collaboration.

In order to facilitate the flexible schedule, there were 2-3 pre-determined working groups assigned to each week. Although the themes provided some structure, and helped participants decide which weeks to attend, the projects and outputs of the event emerged out of the interests and skill sets of the participants involved. All of the collaborations culminated in an interactive exhibition of art and technology on the final day, which was open to the community for several weeks after the event. The themes and working groups of the event included: AI and Machine Learning for Flood Impact; Nature-Based Solutions to Mitigate Flood Risk; Sensing and the "Internet of Things"; Community Mapping with OpenStreetMap; Risk Communication; Social Vulnerability; User-Centered Design; Art and Science for Flood Risk; and User-Centered Design for Disaster Risk Financing (UR Field Lab, 2019). Additional details on the working group activities, event structure, and participants can be found in a previous publication (Soden et al., 2021).

Outputs and Outcomes

Since the UR Field Lab was organized as an "open space event" (Owen, 2008), participants shaped the event as they went along. The topics are decided by the participants, based on their interests and expertise, and the schedule of events emerged from the interests and efforts of the participants. The advertising materials for the event provided three rules for participation: "1) Make something; 2) Document your work; 3) Contribute to the conference community" (UR Field Lab, 2019). Over four weeks together, participants produced both high- and low-tech ways of communicating flood risk, including policy notes, aerial imagery using drones, technical hazard maps, machine learning algorithms, and participatory flood risk maps. In many cases, participants worked on projects associated within their expertise; however, participants were also encouraged to explore areas outside of their field and experiment with other ways of thinking and doing.

Figure 3. Selected outputs from the Understanding Risk Field Lab. (a) 3D model of Chiang Mai, (b) Persona card for flood role-playing game, (c) augmented reality sandbox, (d) elderly residents develop timeline of historical flooding records, (e) board games to support risk-informed decision-making, (f) developing a flash flood sensor with University of Chiang Mai graduate students,(g) participatory risk management map, (h) drone map for flood modeling, (i) "Living with Water" art exhibit.
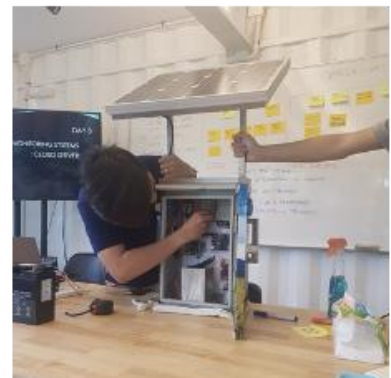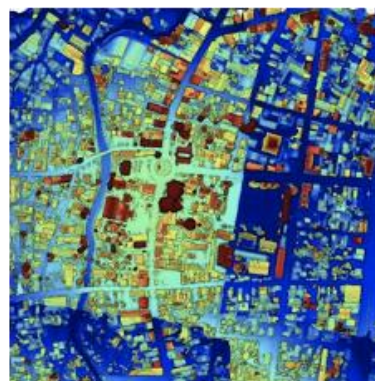
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The output-oriented working format provided several opportunities for participants to work side by side with experts outside their discipline, which was an effective way to develop interdisciplinary work relationships during the event and opened the door to possible future collaborations. In some cases, the interactions produced some friction in understanding. These experiences became constructive moments to recognize the constrained vantage points through which experts build their understanding of the world. For instance, the working group working on AI for flood risk modeling had constructive friction around the concept of 'bias', as understood from a modeling vs social science perspective. Field-based work also allowed technical DRM experts an opportunity to interact with community members exposed to flooding. Additionally, participants from many disciplines were able to share their stories with one another. These real-life flood stories provided a deeper, more meaningful context for the work being done throughout the month.

Attendees came from more than 20 different countries, and the interdisciplinary and international environment was a highlight for many participants (Soden et al., 2021). Many stayed for the entire month, though most came for a shorter period. The attendance at any given day was between 30-50 people. Registration was free, thanks to generous sponsors for the event, so participants were only responsible for their food and lodging. Some scholarships were provided, though most attendees were self-funded. Local participants from Chiang Mai were invited to attend any part of the event at no cost, and many local university professors, government employees, and local non-profit organizations participated in the event by providing data and expertise to the attendees. The organizers of the field lab pre-arranged many of these presentations and partnerships with the local community, though some were invited by the attendees themselves.

The field lab introduced a new way fostering collaboration and interdisciplinary exploration on the topic of urban flooding, and was in the end a very successful experiment. Many new relationships were established through working together, and exit interviews suggested that these new connections and collaborations would extend beyond the field lab event. The projects completed through the field lab experiment provided valuable insights and learning opportunities for the participants, and provided some useful tools and information for the DRM community in Chiang Mai. The location and facilities along with the event schedule and the participants themselves led to meaningful dialogue and the emergence of productive, collaborative work. This event could be replicated for nearly any topic in disaster risk management in many locations around the world to build diverse, interdisciplinary networks that foster creative solutions to the complex problems we face in disaster science. A full account of this event and instructions for creating future Field Labs can be found in Field Lab Guide (World Bank Group, 2020).

Responsible engineering, science and technology for DRM

Description

This last case study features an online knowledge exchange on "Responsible Engineering, Science and Technology for DRM" that lasted for four months from May to September 2020. Our goal was to explore the potential of critical and reflexive practices over a longer time frame by organizing a virtual open space dedicated to the ethics of DRM. We recruited 14 participants via an online call for participation, forming a group of 17 professionals with three organizers from Co-Risk Labs. The call described the general schedule, consisting of a series of two workshops to kickoff the project, weekly meetings with self-organized groups, and

monthly webinars led by experienced DRM practitioners. Participants committed to two things: to engage with the proposed activities, and to have a project that they could use as a case study for the duration of the program. The call highlighted "an opportunity to collaborate with experts in [one's] field on some of the most important questions we face, [allowing participants] to gain: (i) Deep insights into these questions that come from collective and extended investigation over the course of the project, (ii) an expanded network of amazing people who care about these issues as much as you do, (iii) skills and knowledge to help you bring your values and social concerns into your daily work, and (iv) experience and support toward applying these practices in the workplace."

Prior to the workshop, we organized introductory calls (two in two different time zones) where participants and organizers got to introduce themselves, learn about the concepts of critical and reflective practice, and the logistics for the four-month program. We highlighted characteristics of a good project, namely one that is current, tackles issues of resilience, disaster or climate risk management, in an area that you have experience in (i.e. being able to define what is "standard" practice), and involving at least a few people and ideally where you have some level of control.

Two kickoff webinars (each in two time zones) took place on 27-29th of May aimed to prime participants for the 4-month journey. During the webinars, participants were first encouraged to share their hopes and expectations, which helped the group know each other better. We then introduced the concept of "Critical Technical Practice", a niche research area which aims to develop critical thinking by encouraging technical professionals to keep "one foot in practice, one foot in critique" (Agre, 1997). To illustrate the concept, we facilitated an exercise on "inverting metaphors", inspired by the work of other academics working in that field (Devendorf, 2017). This session consisted of a thought experiment helping a DRM practitioner identify assumptions, biases, and values embedded in their practice. Using a case study of participatory mapping, the activity invited participants to identify the metaphor behind the goal to "train citizens to map relevant infrastructure on OpenStreetMap"; then invert the metaphor (e.g., "train citizens to *remove* relevant infrastructure from OpenStreetMap"). This exercise helped us reflect on the assumptions and values associated with the initial goal, an accepted DRM practice of participatory mapping, by thinking about the methods and tools one might use to subvert it. Following that activity, participants were invited to develop a work plan for the 4-months, identifying potential practices, methods, and themes they wanted to engage with.

Over the course of the event, there were monthly webinars and regular (generally weekly) working group meetings. Webinars featured DRM practitioners who shared their experience and insights into the concept of critical technical practice, the ethics of disaster research and disaster response, and the potential of literature and speculative design as critical practices. The working groups were self-organized around topics of interest, either methods or areas of inquiry, with each participant opting in or out depending on personal interest and availability. The themes were: decolonization, nature-based solutions, historical research, intersectionality and feminism, and participatory research and design.

The exploratory nature of the event lent itself to qualitative rather than quantitative evaluation. Some working groups created tangible outputs such as speculative design of a flood early warning system, academic papers, an annotated bibliography on critical technical practice, and a grant proposal. For qualitative assessment, we collected feedback from participants through their project diaries (shared voluntarily) and informal conversations within the working groups. A key idea that emerged was that the online community provided a space for unique conversations that participants did not have a chance to have in their day-to-day lives. These conversations were about the role of specific practices, inviting participants to scrutinize their works from different perspectives. For example, the working group on historical research prompted participants to examine the different uses of environmental history, and to incorporate historical perspectives to their projects (e.g. teaching environmental science). The conversations also had less practical outcomes, simply encouraging curiosity and exploration of ethical concepts or approaches.

In addition, working groups provided a space for support (professional and personal, especially during the pandemic), ultimately creating a small network of individuals that can be reactivated for knowledge sharing, or future professional events. Conversely, a recurring idea we heard from participants was that the online, voluntary nature of the event was challenging, perhaps even more so during the pandemic. Staying committed and motivated to share ideas and advance on individual projects proved difficult for most participants, given the shortage of time that most professionals experience.

Discussion

The three events allowed us to experiment with numerous *design elements* aimed at achieving the *design principles* described in Section 2. In this discussion, we reflect on important practical elements that enable or impede egalitarian interdisciplinarity, inclusivity, creativity, and reflexivity by influencing the experience of organizers and participants.

Figure 4. Design principles and elements for events that aim to promote CTP
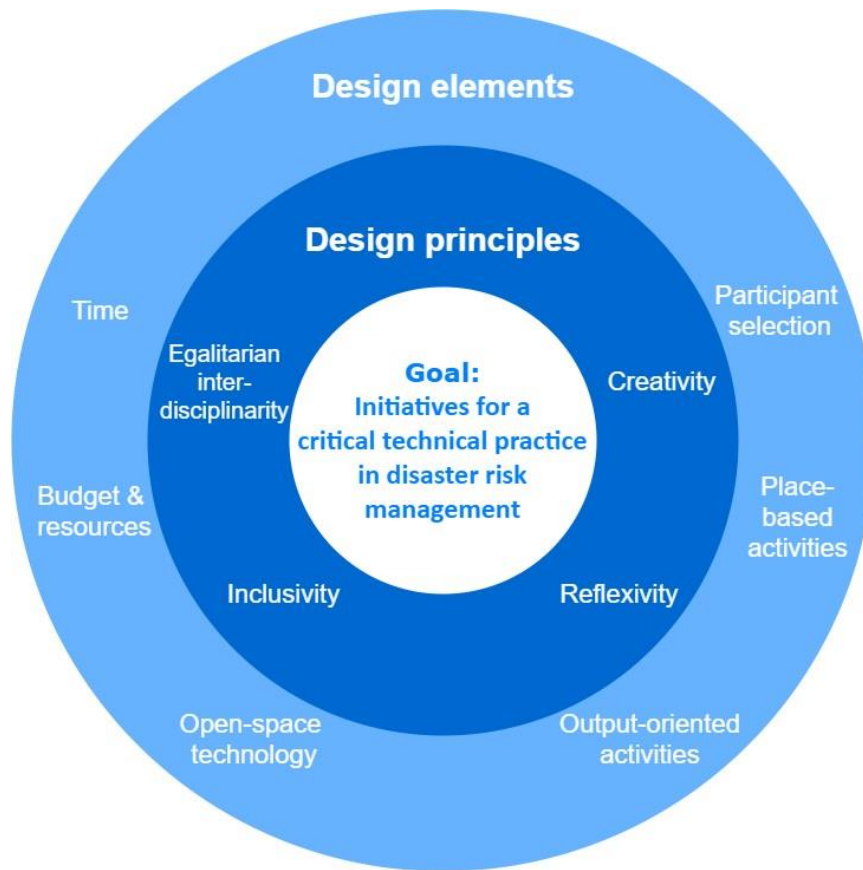
Time

Time was one of the main design elements we experimented with. We found that the short, intensive process of the artathon supported the principle of creativity. The time-constraint forced participants into rapid experimentation, and to find comfort with prototyping and showcasing in-progress work. Yet the focus outputs over such a short time frame resulted in trade-offs on the "authenticity" of the science and engineering: although some participants acknowledged they learnt from different disciplinary perspectives, the outputs prioritized artistic expression over scientific enquiry (Soden et al., 2020).

The UR Field lab embraced the idea that deep work and strong collaborations take time. The language, culture and understanding specific to each discipline can become an obstacle to interdisciplinarity (Rice, 2013), so the extended duration was necessary to enable participants to establish their individual expertise and interests, identify common ground and common language, collaborative momentum with others, iterate divergent and convergent thinking, co-produce outputs and reflect on them. In this process, participants often formed friendships, which greatly facilitated collaborations, and have endured much beyond the time-frame of the event. Not all participants could stay the entire month, so activities were structured in 1-week increments, and a critical mass of month-long participants ensured the transfer of work and knowledge from week to week.

Stretching the timeline even further, the REST4DRM 4-month virtual event experimented with longer time frames, structured around regular sharing and connection activities. The time-in-between was critical to enable participants to reflect on their work, conduct research, or read relevant literature. Participants were free to join working group meetings as they wished, which

can have the undesired effect of losing momentum and motivations for voluntary projects.

In general, while activities are typically structured around pre-defined and standard durations, we have found that time is a critical design element that should be used creatively and intentionally.

Budget

High cost for attendance of events is one of the most direct obstacles to inclusion of broad and diverse participants and stakeholders. Conferences and networking events often cost USD500-1000 for registration alone, and are frequently hosted in expensive cities. For the month-long UR Field lab, we selected an inexpensive and well-connected location, and further provided funding to cover flights, accomodation, food and living stipends for selected participants (20 people). Hence funders are key to ensuring that events are accessible to the wide range of people and stakeholders in DRM issues. From the perspective of organizers, budgets for our events ranged from nearly zero for the virtual REST4DRM event to about USD$50/day/person for UR Field Lab (including venue, logistics support, food, accomodation, flights and stipend), and not accounting for the mostly volunteer work of the organizing team. Sponsors play a critical role to support these events, and can do so through direct financing or providing support staff, sponsoring participants, contributing to outreach and communications, and amplifying the vision and outputs of events through their networks. Existing platforms hosted by international or multilateral DRM stakeholders (e.g. UNISDR, Understanding Risk Forum), provide excellent opportunities to organize events by supporting organizers with technological and communication resources.

Open space technology

An important design element concerns the contents of the event itself, including its structure and the facilitation tools and activities. We used a range of facilitation tools inspired from design thinking and participatory design including "teaching talks" and co-designing of artwork (artathon and UR Field Lab), participatory mapping activities (UR Field Lab), or the facilitation of discussion with an explicit goal to understand other participants' perspectives (UR Field Lab and REST4DRM). Perhaps the most important choice was the use of an "open space technology" (Owen, 2008). Open space events are inherently self-organizing and empowering participants to co-design the event and lead discussions and projects.

With its goal to reduce power asymmetries, open space technology was particularly useful to promote egalitarian interdisciplinarity and creativity. It obscures distinctions between organizers, panelists, participants, or sponsors, and gives participants flexibility to explore topics however they decide. Our events used different degrees of open space technology (Table 1): the artathon left only a few hours of unstructured activities, while the UR Field Lab and REST4DRM embraced open space principles to a much larger extent. During the UR Field Lab, the organizers provided thematic areas of work, but the participants collectively decided on their goals, outputs, methods, workplan, and more, with the only requirement to share progress at the end of the week. The virtual and asynchronous nature of REST4DRM challenged the notion of open space though: while in theory, the virtual space allowed participants to create ad-hoc activities and working groups, it also made it extremely challenging to create the momentum needed for participants to be proactive. Creating active online communities is possible, as social media would attest, but careful reflection on the incentives for participation is needed.

Place-based activities

Another important design element is the idea of designing place-based activities. The selection of Chiang Mai for UR Field Lab was our most intentional experiment with this, and helped anchor the work around the local context. The participants and co-designers of the activities included local universities, civil-society groups and community members, including people impacted by floods. We found that place-based activities were particularly conducive to promoting the principles of inclusion and reflexivity. The engagement with place, community and stakeholders was also instrumental to broader reflexivity, as it served as a near immediate test and confrontation of ideas and prototypes against the compex, social, environmental, historical, political and economic reality of an actual place. The reflection engendered by this confrontation is very constructive, and difficult to trigger in conference rooms and workshops disconnected from context.

Output-oriented events

The three events were all to various degrees output-oriented. The artathon had a target to produce art pieces to be exhibited at a gallery in San Francisco and at Stanford University in the weeks following the event. The first of the three rules in the announcement of the UR Field Lab was to "make something." This output-focused design element helped crystallize interdisciplinary collaborations around concrete production. The process of production itself was further conducive to interdisciplinarity, since it required a broad set of skills beyond abstract thinking or technical analysis, including design, writing, multi-media production and more. The focus on outputs also spurred creativity by emphasizing prototyping, testing, and the development of tactile outputs.

However, the output-oriented design element was sometimes at odds with the goal of reflexivity. For both the artathon and the UR Field Lab, we found that the focus on an "output" created time-pressure which often foreclosed deeper reflection or solicitation of further perspective. In addition, the outputs-oriented ethos was particularly in-line with solutionist reflexes, one of the very issues we are attempting to address. Importantly, we found that it was possible and important to encourage reflexivity before, during and after production, and promote a broader vision of potential "outputs," (e.g. outputs don't have to be instrumental). For the REST4DRM event, given that the output production was not time-constrained, we saw the opposite effect of a focus on reflection rather than high productivity.

Participant selection

Participant selection is a key design element to support values of egalitarian interdisciplinarity and inclusion of diverse perspectives and stakeholders. In all events we selected participants from diverse countries, disciplinary, and professional backgrounds. There is also an important self-selection bias in all events, with the participants applying to the events often finding themselves drawn to other fields or practices.

In highlighting these design elements, we share examples of some key features around which DRM stakeholders can promote important principles of interdisciplinarity, inclusivity, creativity, and reflexivity and others. While these design elements will often generalize across a broad range of projects and events, they nonetheless form a non-exhaustive list. Many other design elements are opportunities to promote critical and reflexive practice. While there is no didactic process for critical technical practice in DRM, the design elements and characteristics described in Table 1 can serve as examples and points of reference for practitioners, policy-

makers and technical experts seeking to design more equitable and impactful DRM programs.

Table 1. Key design elements and characteristics for the three events.

	Artathon	UR Field Lab	REST4DRM
Time	• 2 days	• I month	• 4 months
Resources & Budget	• medium time commitment (for organizers), less for participants • low budget (but more would benefit follow-up projects)	• important budget (but the location made it more affordable) • high time commitment (for organizers, flexible for participants)	• very low budget (online meeting platform, virtual space) • flexible time commitment
Open space technology	• part of the event used open space technology (proportionally less than other events)	• event designed as an open space from the start (main constraints were the weekly themes and art exhibit) • physical space facilitated implementation	• designed in the form of a Slack virtual space • asynchronous interactions made it difficult to benefit from the advantages of open spaces
Place-based activities	• in the set-up but not reflected in all outputs	• focus on Chiang Mai (regional, municipal, and neighborhood scale), helped constrain some projects and encouraged learning from each other	• no geographical focus as each participant brought their own project
Output-Oriented	• strong focus on art production: each group was tasked to produce one art piece • time-pressure for output constrained opportunities for broader reflectivity	• numerous and very broad outputs based on the expertise and availability of participants to contribute • participants each came with projects in mind, and the outputs emerged out of the combined expertise and experience of the group	• outputs emerged organically from individual or group discussions and work
Participant Selection	• online call for participation • participants were chosen based on short essays describing their motivation, experience in their fields and art/science collaboration	• participants were chosen based on their relevant work experience (CV) and project proposals • Intentional selection for diversity of disciplines and experiences • lowered cost barrier to participation by offering scholarships to participants who needed it	• online call for participation • selection based on their proposed project (relevant to DRM) • Intentional selection for diversity of disciplines and experiences

Conclusions

While advances in the identification, quantification and analysis of climate and disaster risk have enabled powerful new DRM strategies, the field has come under criticism for defining risk and resilience in narrow ways, for valuing technical disciplines over others, and not incorporating the broad stakeholders of risk including at-risk communities. The emphasis on technical fields has encouraged the over-simplification of DRM issues, and has hampered the engagement with the social, historical, political, institutional and structural complexities that make up complex social-environmental issues of disaster and climate risk. Principles of interdisciplinarity, inclusivity, creativity, and reflexivity have been identified as instrumental to overcome some of the challenges pervasive in DRM.

While there is no silver bullet or simple framework to ensure the incorporation of these principles in DRM projects, this paper serves four purposes: it (i) highlights the need for a more *critical technical practice* in DRM, (ii) describes some of the design principles such practice should incorporate, (iii) provides examples of three events/projects aspiring to such principles, and (iv) describes a few generalizable design elements that can be used as features around wich critical technical practice can be implemented.

Through the three case studies--an Artathon in San Francisco, the Understanding Risk Field Lab in Chiang Mai, and an online working group on Responsible Engineering, Science, and Technology--we illustrate how researchers and practitioners can promote principles of interdisciplinarity, inclusivity, creativity, and reflexivity in the design processes of DRM practice. Key design elements that help operationalize the design principles include broader creativity in the use of time and resources, use of open space technology to fully empower participants, place-based activities to ground and test assumptions in real contexts, a focus on output production, and careful selection of participants to gain the benefits of interdisciplinarity and inclusivity. We propose that more intentional consideration of these principles when organizing workshops, outreach events and professional collaborations can help the DRM field shift towards a more *critical technical practice*, and in so doing, be better able to respond to the complex challenges of climate and disaster risk.

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