

A Post-Functional Exploration of an Alternative Infrastructure Design Methodology in Adaptive Flood Risk Management Practice

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Problem Statement

This study investigates the potential operational power of a collaborative design methodology that integrates community interests into professional flood management infrastructure practice. Flood management infrastructure projects – including large-scale flow-control structures like dams and levees, as well as smaller interventions such as culverts and detention basins – are primarily designed in institutional collaboration between public works agencies and private technical consultants, effectively excluding the lived experiences of those most affected by flooding impacts from conventional design practice. To address this omission, the proposed study utilizes Research through Design (RtD) principles to explore the functionality of an alternative design methodology: a collaborative 2-person workbook that integrates asynchronous contributions from practicing water infrastructure engineers and at-risk community members.

Flooding is the most commonly experienced natural hazard in the United States, and the most costly recovery for property value and human health [1]. An essential function of flood management infrastructure is to manage water resources in a way that protects people and property from harm. However, due to the complex nature of flooding problems, there is no singular or objective approach to effective flood risk mitigation [2,3]. Conventional best management practices assign decision-making authority to an “expert class” of professionals, who typically prioritize hazard-driven approaches that rely on large-scale, engineered infrastructure systems to replace natural water management capacities. These interventions, rooted in 19th and 20th century American ideals of economic development and human mastery over nature, are often framed as acts of “improvement,” “taming,” or “correction” of the natural landscape, and reflect a utilitarian approach to risk management, aiming to achieve “the greatest good, for the greatest number, for the longest run” [4,5]. Extant literature, as well as ongoing research by our research team [6], recognizes embedded practices of responsibility transference, value-neutrality, privileged legitimization of positivist epistemologies, and bias towards techno-managerial solutioning as predominant in the conventional flood management infrastructure design process [7-11].

Thus, while largely relied upon to generate our water infrastructure, conventional approaches to flood risk management fail to achieve alternative objectives, such as equitably protecting public welfare, as identified by the Environmental Justice (EJ) movement [12]. Indeed, the consequences of insufficient design practices are recognized by the industry itself, as the most recent American Society of Civil Engineers (ASCE) Infrastructure Report Card rates our national stormwater infrastructure as D-grade, citing “few dedicated funding sources,

complicated governance and ownership structures, expansive networks of aging assets, increasingly stringent water quality regulations, and concerning climate change projections” as reasons for declining performance [13]. Additionally, EJ research recognizes that those at the margins of society experience additional risks to their health and safety in the event of flood management infrastructure failure because they lack the resources to prepare for and recover from hazardous flood events [14]. As primary decision-makers whose authority is “bolstered by the environmental hazards associated with the industrial system,” engineering practitioners have significant influence over the outcomes of flood management infrastructure design, and are “deeply implicated in creating and maintaining environmental injustices” [15].

The conditions of professional practice in flood management infrastructure engineering, along with drivers like progressive regulatory policy and worsening climate change, necessitate the development of innovative methodologies for design that confront the shortcomings of existing approaches. These methods may challenge the entrenched power dynamics and knowledge privileging systems that are reinforced within flood management infrastructure design while elevating community members who are directly impacted by the infrastructure to positions of active collaboration in the design process [16]. Additionally, they might offer “multiple unique (situated) perspectives co-exist and constitute the world,” and emphasize how human knowledge can never be decontextualized or abstracted [17]. Such alternatives could subvert the notion that there is a superior “way of knowing, of ‘solving,’ that is better than the old and local and blue-collar and municipal and unionized and customary ways” [18]. Several fields of research, including human-centered or user experience design, are working to expand the existing methodological toolbox available to designers and provide guidance for meaningful community engagement practices that situate human perspectives and experiences.

An example of one such alternative methodology that is popular in recent literature is *participatory* or *community-based* design. Participatory Design situates a community “as a co-creator and collaborative partner,” and promises to allow those “who are directly impacted by a phenomenon or technological intervention to play an active role in the design process and the ways problems are defined” [16]. Such practices challenge “the structure of the designer as domain expert,” and instead center “the community resident as expert based on their lived experiences” [16]. However, as the application potential of participatory practices are increasingly explored, several studies have identified barriers to implementing community-engaged design, including skepticism among impacted communities due to the complex history of research and civil development injustices, risks to privacy and protection of sacred knowledge, maintaining the logistics of facilitated multi-partner collaboration, and “potential decentering of community interests due to valorization of technical innovation along with corporate notions of design” [16]. Other scholars argue that trying to modify conventional practices within institutions of design neutralizes their transformative potential, and call for democratic design decision-making that challenges the very foundations of engineering decision-making [19].

Given these limitations, this study pivots to a post-functional exploration of participatory design through RtD, wherein the process of developing and implementing the alternative method for design (co-produced workbooks) serves as its own reflexive critique of the opportunities and challenges involved in applying transformative practice. RtD encompasses research which produces material artifacts, and describes the process of generating knowledge through the creation of things [20]. Furthermore, post-functional RtD is a practice of critical making that calls for “one foot planted in the craft work of design and the other foot planted in the reflexive work of critique,” by combining “critical thinking, typically understood as conceptually and linguistically based, and physical ‘making,’ goal-based material work” to perform “practice-based engagement with pragmatic and theoretical issues” [21,22].

In this research, the end product is an artifact, but the artifact itself is not the ultimate goal [23]. Rather, the act of shared construction is “a site for enhancing and extending conceptual understandings of critical sociotechnical issues,” allowing for the interrogation and negotiation of “politics of race, class, gender, and ability alongside imagined futures that introduce societal implications” for flood management infrastructure design [22,24]. Using RtD, this methodology will explore its own accessibility, reciprocity, and achievability from the perspective of both community and professional design partners [25]. Thus, the proposed methodology is not intended as a solution to systemic inadequacies of infrastructure design, but rather as a means of self-critical inquiry into how design processes are shaped by and may adapt under broader socio-political forces.

To those ends, this research project aims to apply a self-critical intervention to the conventional design process that explores opportunities and barriers to meaningful community participation in the generation of flood management civil infrastructure solutions.

Methods

The proposed study intends to meet its research objectives through a multi-stage approach, which is detailed in Table 1 below.

Table 1: Outline of the research procedure.

Stage	Description
(1) Development	<ul style="list-style-type: none"> <li data-bbox="553 1570 1398 1717">● <i>Workbook Kit Design and Development:</i> Creation and refinement of a comprehensive workbook and kit of accompanying crafting materials that will serve as the primary tool for engaging participants throughout the research process. <li data-bbox="553 1730 1398 1875">● <i>Participant Recruitment:</i> Relationship building with a diverse group of stakeholders, including community members from socially vulnerable populations and design professionals in the Seattle area. Recruitment efforts will be guided by existing

	community/professional networks (15 civilian & 15 practitioners).
(2) Application	<ul style="list-style-type: none"> ● <i>Introduction and Intake Interviews:</i> Formal introduction to the project objectives, methodologies, and the workbook kit for community and professional participants, including semi-structured intake interviews to gather baseline data on participants' backgrounds, experiences, and expectations for the workbook tool. ● <i>Period of Use:</i> 12 weeks, during which participants will be paired up and will swap workbooks once a week to facilitate collaboration and mutual learning, as each participant will engage with the perspectives and contributions of their partner while completing their own exercises. Expected workload of ~5 hours/week (compensated at \$20/hr). ● <i>Outtake Interviews:</i> Following the active workbook period, semi-structured outtake interviews will be conducted with all participants, intended to capture participants' reflections on the workbook process and the perceived impact. These insights will be critical for evaluating the effectiveness of the workbook kit and the overall research methodology, and for informing adjustments or improvements for future iterations of the project.
(3) Analysis	<ul style="list-style-type: none"> ● <i>Content Analysis of Workbooks and Interviews:</i> Material content from the workbooks and the data from both the intake and outtake interviews will be explored using qualitative content analysis methods to identify key themes, patterns, and insights that emerged during the active workbook period.

The collaborative workbook concept is based on previous research efforts, including but not limited to Bespoke Booklets (Desjardins, Key, Biggs, and Aschenbeck) and Conversational Composites (Gamboa, Ljungblad, and Sturdee) [17,26]. In line with its theoretical foundations, the workbook will be an asynchronous design tool that allows for both passive and active creative collaboration between a paired design team (one individual community member and one flood management infrastructure engineering professional) on a local flood management infrastructure project. The workbook will be a tactile, multi-media artifact that includes prompts intended to facilitate epistemological layering, provoke transformative thinking, and bridge stakeholder values through multiple forms of crafting and reflexive exercise. To ensure that the tool is accessible and manageable for design team members, the workbook will be designed to have a low labor burden (about 5 hours per week), for which the participants will be compensated. Additional challenges to continuous participation, such as logistical breakdowns,

design attrition, or uneven partner contributions will need to be anticipated and prepared for by the design team.

As outlined in the methods table, the workbooks will be exchanged between design team members for an estimated 12 week period, with each team member having access to the workbook and their weekly prompts on an A/B alternating schedule. At the end of each week, the research team will collect the workbooks and crafting kits and return them to the other design partner, who will be prompted through their own exercises to annotate, reflect, and build upon the work from the week before. Over the course of the project, the goal is that the design team broadens their expectations for what flood management infrastructure design might look like within the related project and in the local community, and bridge alternate values and forms of knowledge, resulting in an in-depth, collaboratively developed product that subverts the traditional *alternatives analysis* process of flood management infrastructure design work.

Key Findings and Implications

The expected outcomes of the proposed research will be both material (workbooks) and discursive (interviews). Firstly, the *Development* stage of the methodology will produce a skeleton for collaborative design in the form of an unused workbook. The *Application* stage will then result in multiple context-dependent, co-generated flood management infrastructure design products (i.e. finished workbooks). These completed workbooks will document the efficacy of mutually beneficial flood management infrastructure design information oriented around shared values and pluralistic knowledge. Finally, the project will include documentation of the collaborative process in the form of semi-structured interviews and participant reflections, which will be analyzed in the third stage. This documentation will include feedback from community and practitioner stakeholders about how well the workbook methodology met each of the guiding principles, which may help inform the design of other intervention tools or allow for iterative design of the workbooks.

On the whole, RtD exploration of alternative infrastructure design methodologies can have far ranging implications for civil infrastructure development and public welfare, including 1) reducing maladaptive adaptation practices which compound the impacts of climate change hazards; 2) contributing to socially just research that benefits underrepresented or underserved communities; and 3) bridging theoretical insights and technical practice to illuminate achievable routes to transformative design. An RtD project of this kind offers a structured opportunity to explore alternative best management practices that reduce the uncertainty (and associated financial and professional risks) of challenging the industry status quo. While the workbook products of this study will be inherently grounded in local contexts, the research team expects that the RtD process documentation will produce valuable insights for implementing transformative practice in engineering design at large.

Lastly, as a post-functional application of RtD principles, the process of *generating the design solutions* (i.e. filling out the workbooks) in this project will be just as valuable a research finding, if not more so, than the resulting *design solutions* (i.e. completed workbooks) themselves. The ultimate goal of this study is to contend with the challenge of manifesting theoretical discourse into material practice. Even where the workbook methodology turns out to be an imperfect intervention, there is much to be learned from the process of attempting its implementation that will be relevant to design contexts beyond problems of local water resource management.

References

1. Homeland Security. Natural Disasters. <https://www.dhs.gov/natural-disasters>. (2022).
2. Sova, C. A. et al. Multi-level Stakeholder Influence Mapping: Visualizing Power Relations Across Actor Levels in Nepal's Agricultural Climate Change Adaptation Regime. *Syst. Pract. Action Res.* 28, 383–409 (2015).
3. Schmidt, J. A. Changing the Paradigm for Engineering Ethics. *Sci. Eng. Ethics* 20, 985–1010 (2014).
4. Morgan, R. A. & Smith, J. L. Premodern Streams of Thought in Twenty-First-Century Water Management. *Radic. Hist. Rev.* 2013, 105–129 (2013).
5. Gifford Pinchot and the Making of Modern Environmentalism. (Island Press/Shearwater Books, Washington, DC, 2001).
6. Murray, A. F. & Gordon, B. M. Identifying Equity-Related Decisions in Flood Management Infrastructure Design: Insights from Practitioner Interviews. in *Engineering Project Organization Conference* (Engineering Project Organization Conference, Bar Harbor, Maine, USA, 2024).
7. Nightingale, A. J. et al. Beyond Technical Fixes: climate solutions and the great derangement. *Clim. Dev.* 12, 343–352 (2020).
8. Huesemann, M. & Huesemann, J. *Techno-Fix: Why Technology Won't Save Us or the Environment*. (New Society Publishers, Gabriola, B.C, 2011).
9. Riley, D. Engineering and Social Justice. *Synth. Lect. Eng. Technol. Soc.* 3, 1–152 (2008).
10. Mikulewicz, M. Thwarting adaptation's potential? A critique of resilience and climate-resilient development. *Geoforum* 104, 267–282 (2019).

11. Mikulewicz, M. Politicizing vulnerability and adaptation: on the need to democratize local responses to climate impacts in developing countries. *Clim. Dev.* 10, 18–34 (2018).
12. Wasley, E. et al. Chapter 31 : Adaptation. Fifth National Climate Assessment. <https://nca2023.globalchange.gov/chapter/31> (2023) doi:10.7930/NCA5.2023.CH31.
13. ASCE. Report Card for America’s Infrastructure. <https://infrastructurereportcard.org/cat-item/stormwater-infrastructure/> (2021).
14. Cutter, S. L., Boruff, B. J. & Shirley, W. L. Social Vulnerability to Environmental Hazards. *Soc. Sci. Q.* 84, 242–261 (2003).
15. *Technoscience and Environmental Justice: Expert Cultures in a Grassroots Movement.* (MIT Press, Cambridge, Mass, 2011).
16. Harrington, C., Erete, S. & Piper, A. M. Deconstructing Community-Based Collaborative Design: Towards More Equitable Participatory Design Engagements. *Proc. ACM Hum.-Comput. Interact.* 3, 1–25 (2019).
17. Desjardins, A., Key, C., Biggs, H. R. & Aschenbeck, K. Bespoke Booklets: A Method for Situated Co-Speculation. in *Proceedings of the 2019 on Designing Interactive Systems Conference* 697–709 (ACM, San Diego CA USA, 2019). doi:10.1145/3322276.3322311.
18. Maggie Gram. *On Design Thinking.* nplusone (2019).
19. Cooper, D. Prefiguring the State. *Antipode*, 49(2), 335–356. (2017). <https://doi.org/10.1111/anti.12277>
20. Zimmerman, J., Forlizzi, J. & Evenson, S. Research through design as a method for interaction design research in HCI. in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* 493–502 (ACM, San Jose California USA, 2007). doi:10.1145/1240624.1240704.
21. Howell, N., Desjardins, A. & Fox, S. Cracks in the Success Narrative: Rethinking Failure in Design Research through a Retrospective Trioethnography. *ACM Trans. Comput.-Hum. Interact.* 28, 1–31 (2021).
22. Ratto, M. Critical Making: Conceptual and Material Studies in Technology and Social Life. *Inf. Soc.* 27, 252–260 (2011).
23. Bowers, J. *The Logic of Annotated Portfolios: Communicating the Value of ‘Research Through Design’.* (2012).
24. Harrington, C. N., Klassen, S. & Rankin, Y. A. “All that You Touch, You Change”: Expanding the Canon of Speculative Design Towards Black Futuring. in *CHI Conference*

on Human Factors in Computing Systems 1–10 (ACM, New Orleans LA USA, 2022).
doi:10.1145/3491102.3502118.

25. Wallace, J., McCarthy, J., Wright, P. C. & Olivier, P. Making design probes work. in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems 3441–3450 (ACM, Paris France, 2013). doi:10.1145/2470654.2466473.
26. Gamboa, M., Ljungblad, S. & Sturdee, M. Conversational Composites: A Method for Illustration Layering. in Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction 1–13 (ACM, Warsaw Poland, 2023). doi:10.1145/3569009.3572793.