The Agony and Ecstasy of Extended Research on Computational Systems

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Abstract

This collaborative "essay of essays" begins with an introduction by a professor of human centered design and engineering who has been working concurrently with PhD students to study collaborative system design. We undertake widely scoped qualitative research studies, that we categorize as "extended studies," that cut across units of analysis, organizations, or time. Our research explores how people create new ways to enact systems that support the knowledge work of different stakeholders. In response to an anchor essay, the students have written reflections about the multifaceted experience of doing extended studies. Many of these studies began by focusing on a particular project to develop a particular system or information infrastructure, and associated standards. Over time the studies came to center on collaborative dynamics *per se*, and also how collaborative dynamics shifted the scope and functionality of products, sometimes also affecting programmatic and infrastructural level changes.

CCS Concepts

• **Human-centered computing → Collaborative and social computing theory, concepts and paradigms**.

Keywords

CSCW, Ethnography, Qualitative Research, Infrastructure, Crisis, Long-Term, Complexity, Complex Systems

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1 Introduction

Even after becoming a full Professor in Human Centered Design & Engineering (HCDE) the influence of my PhD advisor runs deep. His influence runs deep in the way that a water table can be beneath the surface, subterranean, and yet a current is always flowing. After introducing my own scholarly influences, I present an anchor essay below, entitled *Reaching and Plodding for the Stars*, to which my PhD students then respond with their own essays, reflecting on issues ranging from changing relationships with field sites, understanding the meaning of a crisis, rupture and inflection points, the recreation of stability, and the kinds of objects of study that extended research makes possible. We undertake these kinds of studies in order to investigate how people iteratively redefine sociotechnical contexts and problems to inform meaningful and effective process changes for tool, system, and infrastructural design.

I came to the field of HCI and CSCW with two degrees in Sociology, one from UC Berkeley where my professors were renowned for their qualitative research. One of my favorite courses was the first semester of Sociological Theory. The professor for the course, Michael Burawoy, was a deeply respected, internationally renowned scholar. He was a modest man, yet one who did research boldly. He studied factory work and the organization of work, and related those to exploration of class and social structure. He also promoted extended case methods to, among other things, "extract the general from the unique, to move from the 'micro' to the 'macro,' and to connect the present to the past in anticipation of the future [5]. The seeds were then planted in my mind already to wonder what interactions and theory might lie in between everyday practice and larger social structures.

At UCLA I was Phil Agre's only doctoral student. At times I would retrieve books and articles for him. He was very interested in the possibilities and dangers of the network effects of IT. Among other things he wrote about AI and privacy. Underlying these explorations were two specific and deeply held concerns: 1) the coupling

of technology and values of rationalization (e.g. logic, especially for efficiency); and 2) the importance of social institutions [1]. He saw action and organizations as crucial for understanding and influencing how technology and institutions support and constrain action. It distressed him when writers would throw out the "baby with the bathwater" and use the limits of rationalization, which deeply concerned him, to also tear down the importance and usefulness of institutions and regulation. It was then that I started to think about information, social networks, and ecosystems. After UCLA, my postdoctoral advisor at UC Irvine, Paul Dourish, led me to the study of infrastructure *per se* and to the fallacy of designing technology without care or concern for the material or embodied [6].

In studying collaborative design, development, and maintenance across organizations and for long periods of time, we are able to see pivotal moments when infrastructural systems are being brought together and created. These moments can include negotiations and sensemaking around specific data products, snippets of code, instruments, and changes in priorities and human resources. Exploring this multiplicity enables us to study the collaborative design of design itself. My students are two generations removed from the direct influences of my own professors. They are branching off from here, doing their own explorations.

2 Anchor Essay: Reaching and Plodding for the Stars by Charlotte Lee

Our goal with our research is to create concepts, methods, and tools to better inform the design of computational systems that support complex collaboration. It is this kind of complex collaboration which is necessary in the production of knowledge, not only in contexts of science and engineering research, but also in business process support, experimentation with artistic expression, or with any group of people who need to get together to assemble, work through, and make sense together of information, ideas, and values to come up with a plan of action.

The message we sometimes get seems to be that qualitative researchers have no business studying complexity–that is for statisticians. I don't agree. Judging from a seeming resistance to my urging to do less, my students don't agree either. Yet I feel bad that it takes so long to do these studies well. The demands for dedication, perseverance, and dollars are high. I say repeatedly, "Stop collecting more data." I say, "Scope it smaller."

The extended research we conduct primarily entails undertaking research studies that have broad coverage across linked organizations, both formal and informal. Broad coverage can include multiple teams and organizations working together or people working across functional units within a large organization. Extended research can entail undertaking long-term research studies. Long term research has been written about extensively in additional fields. In a broad sense, "extended" methods can mean the connection of field sites to wider contexts [5], following actors through their own activities of scaling [20], following artifacts across sites [31], or the construction of associations between "chains, paths, threads, conjunctions, or juxtapositions of locations" ([17], pg. 105). Increasingly, it can mean extending ethnographic engagement from shared spaces into the digital mediations and other interactional resources that make up contemporary contexts of work and life [2]. Similar to Latour [13] who urges us to "follow the network" and to Engeström's discussion of [8] "knotworking" where it is understood that the locus of initiative changes, we study how open systems evolve. However, we do this work as part of an interrogation of collaborative design.

We have gotten well-intentioned reviewer feedback, on more than one occasion, that a paper is "too ambitious" or that papers should be limited "to only one level of analysis". However, I cannot see how a smaller purview can help uncover the sociotechnical dynamics of the integration of systems needed for discoveries in ocean science, astronomy, transportation engineering, disaster resilience, etc. The people we study grapple with "wicked problems" which are complex and difficult to solve. Our study participants proactively find collaborators, learn and negotiate, identify new problems, and undertake interactional change, design and development of new standards, tools, equipment, and systems. We want to know how they do it. In turn, they want us to tell them how to do it better.

Without enough funding for a team large enough to study the qualitative dynamics of an infrastructural system in its entirety, researching for a long time provides us with one way to study more teams and organizations than we could in a "regular" short project of several months. Though we cannot be in different places at the same time, we have more options to be in different places at different times or the same place at different times. The situation and the solutions are imperfect but it is one tactic for seeing what we want to see. At the same time, the onset of COVID-19 presented an opportunity where the crisis, in a sense, "sped up time", enabling us to see a profusion of interactional change and bending of institutional boundaries.

Several years is a very long time for HCI research. Furthermore, we are in a College of Engineering. However, our department allows, if discourages, taking several years to complete a PhD. This extra time affords qualitative research in "fieldsites" for years. I place the term "fieldsites" in quotation marks because at different times we have more roles than social scientists doing work in the field. Sometimes we also become collaborators, employees, experts, institutional memory, even pals. What even is a "study participant" when you're talking about people who you have known, and have sat in design or scientific meetings with, for several years? My students often spend more time with their research participants than with our own lab members. My own research participants have known more about my Achilles tendon surgery recovery than people in my own department. Anthropologists recognize that being in the field already changes the field [10]. This is true for us as well. Our priorities and experiences can differ, however, due to our primary commitment towards developing theoretical knowledge about coordination and collaboration and informing or participating in collaborative design.

Extended approaches can mean constructing the field around concepts such as infrastructure, which are emergent and open-ended in their development [12]. The corpus of infrastructure literature [7, 11, 15, 21, 24] provides approaches to framing our own research questions. Extended approaches can also mean the extension of the typical flashpoint of a crisis or disaster into the long trajectory of decisions and organizational shifts that precede and contextualize it [29]. While the long-term is a typical characteristic

of our approach to extended research, it is not definitive. Our particular concern is the nexus between technology and organizationally situated social interaction that is shaped and shaped by institutions.

Below we reflect on the experience of conducting extended research studies which entail qualitative research that is extended across organizational boundaries or is long-term. Most, but not all of our projects are both. Extended engagement allows us to view larger problem spaces and to see how a myriad smaller design problems and projects comprise larger ecosystems of networked and overlapping projects. This form of engagement resembles Marcus's "multi-sited ethnography" [17], in that it commits us to "follow" various aspects of a project across times and settings, and requires a level of theoretical flexibility to compass all the phenomena we are interested in. However, our investment in design and system development add both new objects of study and new complications.

3 Reflection Essays by PhD Students

The following essays by members of the lab, my PhD students, explore these and other dynamics in the extended study of computational systems. Theories such as articulation work, coordination, and collaboration [3, 9, 18, 23, 26, 27], provide inspiration and common conceptual grounding, but lead in many different directions. Prompts that I shared, in addition to this introduction, included questions such as: How did what you think of the phenomena of study change over time? Why was the long term needed? How did your relationship to the people participating in your study change over time? How did you manage doing research and design? Each project engages deeply with only a subset of concerns, such as data sharing, software development, design methods, materiality, sensemaking, and organizing. In the essays below, the authors reflect on how our extended research provokes investigation of the following: the meaning and bounds of fieldsites and design projects (LeDoux), the changing objects, periods, and rhythms of work (Sutherland), the intensity and density of interactions in short term research on a crisis (Alimohammadi), and how new phenomena and science project directions are constituted in relation to the formation of problems and data integration (Neang).

3.1 Formations and Reformations of Crisis by Ridley Jones LeDoux

LeDoux's piece describes how a complex inter-organizational design project informed her understanding of what a "fieldsite" was: the changing configuration of participating organizations and workgroups affected how it could be designed for and how it absorbed different kinds of crisis over time. These experiences show how an extended approach creates needed visibility for effective infrastructural design and research.

As experience in this extended project grew over time and depth of engagement, I both learned and un-learned what a "fieldsite" and what a "design" project could be in a complex, interagency public sector setting. Similarly, I re-evaluated my own lens on "crisis"– both those crises that rolled through and reshaped my fieldsite, and moments of intellectual development I gained through my experiences in it.

As a member of my advisor's lab, I have been working in varied design and research capacities in an extended public service infrastructure project since 2018. The project brings together agencies at different levels of government (city, state, county, and regional) who provide service of various kinds during major traffic incidents. Their work has many and vivid temporalities, from the intense few minutes of detection and acute response after a crash, to the month and sometimes years of analysis and infrastructure investment that can result. Together, they must reckon with each other's different work specialties, sometimes with conflicting goals, and attempt to find ways of coordinating and sharing the work across jurisdictions. Our goal was to create, for the first time, a technology system they would all share, and data they could all see at once.

This required intensive and extensive effort to maintain entree with cautious public service agencies, to delimit operational and jurisdictional issues in coherent ways, and navigate shared ownership of nascent information systems. I was drawn into my project *before* I began working with my advisor, so our growing intellectual relationship also shaped my experience of the project over time. Indeed, I was not the only person in my department working on this project; other scholars with other approaches and commitments have had an engagement with the project as long and intensive as my own. Reconciling these questions–what is a research participant, where are the limits of a project, and to what extent strategic adjustment of design and research methods allows greater insight or only overcomplicates matters–has been a large part of my own intellectual development as a student, and I hope will continue to bedevil me throughout my career.

One particular challenge I have experienced relates to what counts as a fieldsite. The "fieldsite" was both an assortment of public service agencies and the intellectual/organizational/design project they engaged in together. The agencies were striving to improve shared practice and work with us to develop a technology system that would aid in that effort. Both on-the-ground operational work that the group of agencies did, and the work to encapsulate constructs around that work in a shared system, were the "fieldsite," and each changed the boundaries of the other. How often might such imbricating changes be visible with greater access and temporal exposure in other projects?

The longer the project/fieldsite went on, the more difficult it became to clearly identify what a "design project" or "intervention" actually was. This was a bit surprising: after all, a significant period of time was, as is typical, dedicated to problem definition, project planning, and specification of system elements. In that sense, ambiguities were closed and questions were answered. However, this analytical, emotional, and relational lens inevitably got wider. I began to learn about how project-related conversations penetrated the specific organizations participating in the project (and such things were often out of scope and so my curiosity had to be actively curtailed…), and similarly where such changes were hidden from us. What can even become a design input has certain antecedents that the participating organizations may or may not choose to reveal. Simply being aware of this counterfactual, and devising ways to investigate it more thoughtfully earlier in the project, will inform my strategy in future research settings.

With respect to "Computing (X) Crisis," I reflect on two aspects of this project. One is the trajectory of research production. It can

be humbling (though enlightening) to publish work later in engagement which is in dialogue with work by one's earlier, less informed and immersed self. This highlighted the subjectivity of time–or at least the extensivity or intensivity of it–as well. For me, learning and changing my thinking, through what felt like many years of intense experiences, those few years were long. For many of our operational stakeholders, who maintain technology systems, funding structures, and operating procedures for sometimes decades, they occasionally felt quite fast; they would occasionally need to "pump the brakes" to permit their institutional rhythms to keep pace with our design project. The intensity and duration of my engagement caused what were supposed to be "design" activities to bleed into "ethnographic" activities, and vice versa. This shift over time affected what I was able to learn, and therefore the kinds of assertions I was making. Revisiting my prior self in reference to the same project will be a standard part of my methodological toolkit going forward, rather than, as it has sometimes been, an accident of the paper trail of research publications.

Second, in this public service domain, "crisis" is absorbed into the longer-term rhythms of the domain. The COVID pandemic (which affected both economic activity and public use of infrastructure in very serious ways), major public construction projects that strained the service delivery of the stakeholder agencies, and political tides of scandal, funding, and election all played out in the project. They happened, and they caused genuinely significant problems, but they eventually became incorporated into the longer-term planning and service provision of regional government. Ridership projections were adjusted, bridge construction schedules were tweaked, and employee time was repurposed. Being involved as a researcher for a much shorter duration might have hidden some of these rhythms–indeed, it may take decades for yet longer rhythms to emerge!–and tempted us to see any individual crisis in a misleading way. As Roitman [22] notes in *Anti-Crisis*, "crisis" is not a category of thing that can be observed and delimited empirically, but "a logical observation that generates meaning in a self-referential system, or a non-locus from which to signify contingency and paradox. And the judgment of crisis is necessarily a post hoc interrogation: what went wrong?" This has taught me to be cautious about diagnosing the meanings and impacts of particular crises, and suggests to me there is much more to learn in the next decennium.

3.2 Cosmic Fields by Will Sutherland

Sutherland's essay describes how in his work with a research lab in cosmology, specific aspects of scope made new kinds of analytical objects possible, including aperiodic events, rhythms of work, and longer trajectories of projects and careers. He also highlights tensions between this extended scope and the bounding of publishable topics as well as the need to conduct different phases of analysis simultaneously.

The ethnographic work I have carried out over the last few years has been shaped perhaps most by its scoping. In interacting with colleagues in my field, and in reviewing papers, I often encounter (and reproduce) a rationale that rigid scoping of an investigation is a necessity. Stringently delineating the conceptual or organizational boundaries of one's research creates clarity, and it is necessary to accomplish the kinds of parsimonious concepts and publications expected as academic output in many venues. The research group that I work in, however, departs from these expectations, and it was not for a few years that I realized how significant of a departure this was.

The kinds of investigations and action research I see my fellow lab members conducting are broad in the kinds of practices they consider, the sites of work they attempt to connect, and the extents of time and phases of work they look across. These investigations are ambitious in their breadth to the point that it may seem imprudent to some observers, and I can attest that it means contending with myriad problems of scope. However, I have come to realize that it produces kinds of understanding and engagement that cannot be produced any other way, and it allows for a flexibility in the research process that not many other approaches have.

Here I will talk about my own experiences with this kind of approach, through my own 5 year long ethnographic engagement with a research group in the field of cosmology, which I will refer to as the Cosmology Group. My work with this group began in 2019 and expanded along a number of dimensions over time. In parallel with this developing fieldwork, I was beginning to encounter discussions of some of the challenges and generativities of extended work in multi-sited ethnography [17] and historical ethnography [29], among others. For the purposes of this essay, I will focus on a couple basic aspects of scope and some of the ramifications they had in my work: *variety in sites of observation*, *length of engagement*, and *regularity of observations*.

My engagement with the Cosmology Group took me to a number of different sites of their work, which necessarily turned my object of investigation into a multifaceted thing. I initially started out observing in weekly lab meetings, but my investigation eventually took me through software development meetings, paper-based data analysis sessions ("data rampages"), discussion groups, and impromptu student tutorials. The software development meetings consisted primarily of research scientists, rather than the range of people (from Ph.D. students to the PI) who were present at the lab meetings. They were entirely focused on the minutiae of coding and testing software, rather than the science-focused discussions of the lab meeting. They were also rigidly timeboxed, whereas the lab meeting would carry on for hours, as long as there were more scientific issues to be discussed. The two situations presented very different views of the group's work that were hard to reconcile under any single conceptual problem or framing. Even figuring out where I could and should observe required putting together different actors' accounts of old politics, with me following my interlocutors' own scaling activities (see also [29]).

This variety of contexts produced a variety of different kinds of observations that were initially difficult to reconcile in the qualitative coding process, but it also produced a picture of work in the Cosmology Group that considered not only research activities, but also the more prosaic "IT work" that built and maintained some of their most essential research tools. It considered not only contexts of learning and training where Ph.D. students learned the ropes of work in the field, but also the day-to-day banter amongst "old hands" who had been working in the field for a long time. Despite the initial difficulty of combining these different types of observations, the result was a more nuanced view of what is actually entailed in the work of a contemporary research lab.

My engagement with the Cosmology Group also benefited from the length of time considered, which included not only the 5 years of my own involvement, but also a further 4 years of fieldwork done by a prior member of our lab. On joining the group he was able to describe to me the history of their various tools and projects, and the character of different members of the larger collaboration. The extent of our collective interaction with the group allowed us to capture rare, aperiodic events, such as when the group's computing cluster was suddenly disassembled by the university that was hosting it. This created significant chaos in the group's work, and a scramble to assemble new computing resources on the fly. An event of this magnitude of disruption happened only once in the more than 10 years spanned by our two observational periods. We were able to capture the event itself, but also the significant change in routines before and after the event. Other events, such as the data rampage mentioned above occurred only once or twice a year, and would likely have been missed in a shorter engagement.

I was also able to see phenomena that played out over long periods of time, such as the full arc of a Ph.D. student's career in the group, from their early projects and service work to their later dissertation work and talks. The drawbacks of this length of engagement were, in part, that data continued to pour in as I was trying to refine and focus my analysis. New issues and lines of investigation opened up as I was trying to bring other investigations to a close. I was constantly in two or three different phases of data analysis, collecting for one topic, early concept development for another, and writing or explication for a third.

Lastly, my engagement with the Cosmology Group was highly regular, which allowed me to see not only change over time, but also rhythms and cycles of work. My writing on the Cosmology Group ultimately came to focus on tensions between uncertainty and routines, how they structured their research work over time despite unpredictability in the direction and time frames of their projects. This dynamic only began to appear through my regular attendance at lab meetings. I also got connected with group mailing lists and messaging platforms that updated me on every change made to a number of the group's software packages. Establishing co-presence [2] with the group was in part through my own temporal alignment with these rhythms of development work [25]. These regularities in my own engagement allowed me to see departures from a norm and changes in tenor. During the run-up to some of the students' dissertation defenses, or during a reinvestigation of a part of their instrument that might have been malfunctioning, I could recognize a tangible sense of urgency and worry that was not usually present in their lab meetings.

As mentioned in the opening to this paper, this approach to qualitative research is hard to recommend to others, as it necessitates ongoing struggles with information overload and 'messy' [14] overlaps in data collection and analysis. Also, seeing as much as I did of the Cosmology Group's work made it hard to establish a distinct concern explainable in the size of the typical publication. Everything in the field developed connections with everything else, and it became difficult to sequester away any particular part of an ongoing endeavor that seemed to hang tenaciously together. However, it is precisely within this density of connections that the objects of my work–aperiodic events, rhythms of practice, and long-running lifecycles–began to take form. It was not just a matter of going 'deeper', but of making different kinds of things possible and tractable as objects of consideration.

3.3 The Space of Half an Hour by Negin Alimohammadi

Alimohammadi's essay discusses how her work on a large university adapting at the onset of COVID-19 shows how research that is short term, and across groups or organizations, can provide unique insights for extended research. For example, her research explores how individuals and departments quickly reimagine and take action on work practices, roles, and responsibilities to fit an altered landscape.

3.3.1 About the Space of Half an Hour: Ethnographic Engagement in Crisis. During a time of crisis, I undertook brief, intense fieldwork to explore continuity and rupture within and across organizations. In times of disruption, people are acutely aware of how things used to be and how their day-to-day, very ordinary practices are disrupted. The narratives that participants share reflect how they are actively improvising to rebuild old patterns.

I come from a lab that often undertakes long term ethnographic engagement with field sites that are multifaceted and multiorganizational. In our lab, the focus is on expansive scoping and holistic examination of work practices, organizational cultures, and technological development over extended periods. This enables my colleagues to capture the gradual and layered transformations of work as they unfold across diverse sites and temporalities. It is an endeavor that seeks to understand not only what changes but how and why these changes occur over time.

However, my experience as a member of the lab took a different path. It was marked by an unprecedented rupture—the COVID-19 pandemic. I chose to engage with a project that required very fast-paced fieldwork. My study was scoped to be brief and intense, limited to a year, as it was clear from the onset of the pandemic that we had only a short window to capture the rapid reshaping of work processes and modes of collaboration. My team, including members of this lab, selected our own campus, the University of Washington in Seattle as our field site. This large public university was one of the first educational institutions in the United States to transition nearly its entire operation to remote work. This presented a unique opportunity to observe how an organization of this scale navigated the sudden shift to remote work and redefined its institutional practices.

3.3.2 The Space of Half an Hour and the Unfolding of Seven Seals. My fieldwork happened while no one at the university, including ourselves, had the luxury of a phased onboarding into new ways of working. My work unfolded in ways that I later realized could be well described as "the space of half an hour". I learned about this concept through Julie Mehretu's collection of paintings that she created during the COVID-19 period and later named the collection after the biblical symbol of a moment of silence and anticipation before monumental change. It represents a pause before the unfolding of the seven seals, a temporal horizon of continuity, depth, and gradual revelation.

It seems to me that while my colleagues were witnessing the unfolding of seven seals through their long-term engagements

—observing the slow accretion of change the cyclical rhythms of work, and the gradual renegotiation of norms—I was navigating "the space of half an hour." It was a moment of accelerated change and this stood in contrast to the unfolding of seven seals, where my colleagues had the privilege of observing the slow rhythms of organizational life.

Yet, I began to realize that studying a field site during a crisis shares many characteristics with long-term engagement. In times of crisis, people are acutely aware of how things used to be and how they have been disrupted. Their narratives are stories of continuity and disruption and of their attempts to recreate stability while improvising new ways of working. This heightened state of awareness and adaptation reveals the underlying logics and assumptions of organizational life—logics that are often taken for granted in more stable times.

"The space of half an hour," interestingly, was defined by intensity and quality rather than duration. Similarly, our experience of fieldwork allowed us to capture the intensity of change rather than a fully defined characterization of the changes that were taking place. There were so many new working groups, so many reconfigurations of resources, and so many transient moments of caring, helping, sharing, boundary shifting, and innovation. We captured the transient configurations required for establishing stability.

The fieldwork during a crisis added a dimension to my field site that might otherwise be found only in long-term engagements—the reconstruction and pursuit of stability at multiple levels: individual, group, departmental, and organizational. For some, stability meant replicating pre-pandemic workflows as closely as possible to restore a semblance of normalcy. For others, stability emerged through adaptation and synergizing, reimagining work practices, roles, and responsibilities to fit an altered landscape. Inquiring about how people in our field site narrate changes, initiate new efforts, or abandon ongoing collaborations could reveal deep insights into the dynamics of the field site.

The synergy of efforts and actors was another dimension of fieldwork during the crisis that might otherwise be found only in long-term engagements. I came to realize that during a crisis, some individuals and teams became emblematic of ongoing change as they actively used the resources at hand and participated in reconstructing stability. Understanding the relationships and connections within the field site is crucial to identifying these key actors and observing the seeds of change.

In the spirit of the Conference, I also would like to reflect that we observed how the technical infrastructure of computing played a crucial role in sensemaking and meaning-making during the crisis. Forgotten mail servers were reborn as trusted sources of information. At the same time, IT work emerged as a heroic act of enabling, empowerment, and care. IT workers became essential workers throughout the University units, making all other work possible across departments. Narratives of our fieldsite illustrated how their efforts to support people's needs (including but not limited to IT) were closely aligned with the principles of "care work" and values of care. These latter notions prominent in feminist scholarship [28] played a role in sustaining organizational life during moments of disruption.

3.4 Oceanic Sites and Extended Engagements by Andrew Neang

Neang's essay concerns how the collaborative integration of data by diverse oceanographic researchers can reshape how research topics (also known as "problems") are selected and scoped. Through an extended approach that entails broadening coverage across connected research sites and sustaining deep engagements, critical events that shape emergent project trajectories are brought into view.

As part of my PhD studies, I have been conducting an extended multi-sited investigation of how ocean science researchers from different disciplines go about shaping their collaborative data-intensive research projects since 2018. One of my studies examines a collaborative research team spanning multiple academic laboratories across the United States. These researchers are working together to integrate and analyze datasets they individually generated using various omics techniques (e.g.,transcriptomics, metabolomics, and lipidomics) to study marine microbes. A core challenge in these boundary-crossing efforts is hashing out the different orientations, ways of working, and evidentiary practices between disciplines.

These engagements involve more than just sharing datasets or aligning terms; they are problem-focused integrations of work and practice. Therefore, a central dynamic that must be understood when studying such nascent collaborative research projects is problem formation. Research problems reflect from the evolving understanding of what truly matters in an investigation—determining which datasets are pertinent, what methods are appropriate, and what is considered to be both a significant and meaningful outcome. For that reason, examining how research problems are formed in relation to the work of integrating diverse datasets can provide us a better understanding of how collaborative data-intensive research projects take shape and ultimately get taken up by the group as a whole.

3.4.1 Surfacing the Different Stakes and Interests of Ocean Science Researchers. As part of my extended engagement, I regularly attended bi-weekly all-hands data integration project team meetings, weekly meetings held by individual research labs and on occasion those between labs. The all-hands team meetings provided unique insights into the uncertainty members felt about what kinds of biological or chemical research questions they might be able to address together, what data sets to include or exclude in their investigation, what kinds of analyses were appropriate, and what was considered a meaningful outcome to the team. As time passed, I observed how the all-hands meeting evolved into a forum where members would present their research problems and gauge whether they resonated with and motivated the broader group.

The individual lab meetings primarily served as a space for researchers to explore their discipline-centric research problems while also honing the coherence of their analyses and arguments before presenting at the all-hands meetings. These sessions also functioned as reflective spaces where researchers could revisit and refine their proposed problems, making them more engaging and better aligned with colleagues' interests and priorities. My sustained involvement with the project also fostered relationships that earned invitations to strategic meetings where smaller, chemistry-focused research labs gathered to try and protect their core research priorities within

the broader collaboration and ensure their datasets maintained primary importance rather than being sidelined as supplementary material.

Regularly attending these diverse meetings expanded my understanding of each project member's unique priorities and disciplinary driven interests, revealing the complex, unscripted kinds of organizing work required in constructing a shared research problem and direction. This multi-year engagement also allowed me to expand the scope of my investigation through developing key relationships and securing access to inter-laboratory meetings and other private meetings that would have otherwise remained inaccessible. Collectively, these meetings yielded invaluable insights into the coordinative processes undertaken by researchers working across different disciplines.

3.4.2 Working Towards Making Data Integration Possible. Having the opportunity to engage with researchers over the long-term also benefited my research by providing rich insights into kinds of tasks that go on before and behind the work of data integration. Many of the participating researchers on this project have never undertaken the work to make diverse omics data comparable and complementary. As a result, I was able to observe how researchers engaged in the work of developing mutual understanding. I could see how they attempted to provide data to each other and address questions collaborators have about metadata fields and acronyms. Moreover, my investigation provided me with enhanced access to the project lead, allowing me to closely observe his attempts to navigate the challenges around fostering collaborative discourse among members from different research groups, bringing data from one lab to bear on research problems constructed by another, and establishing mutual understandings of data types and working operations.

Making such observations would not have been possible without maintaining a consistent presence. It allowed me to identify and engage with key actors involved in managing the complexity surrounding the absence of a coherent framework and ways of working to help this research endeavor move forward. More broadly, I was able to observe how integrating diverse datasets not only fundamentally altered the direction and focus of research problems, but research problems can similarly reshape how researchers approach data integration.

3.4.3 New Leadership and Changing Research Directions. Following multiple sites regularly over an extended period of time also made it possible to observe specific inflection points that had a profound impact on the overall focus and direction of the research project. For instance, I observed a junior PhD student with statistical expertise and some background in ecology being promoted to the project's leadership role after a postdoctoral researcher's departure. The principal investigators specifically selected this student because they demonstrated the necessary skills to manage the complex work of making diverse omics datasets complementary and comparable for integrative analyses. This shift redirected the project toward a data science orientation, with nearly a two year focus on exploring how time series analytics and machine learning methods could effectively partition and analyze their data sets and less about the general oceanographic implications or conclusions that could be made.

I was also present during an individual lab meeting where one of the principal investigators in biological oceanography recommended her students pitch the idea that the results from the project should focus on helping further expand understanding about an ecological concept known as the "paradox of the plankton" which describes that species that compete for the same resource should not be able to coexist and yet they do. This suggestion was warmly received by the biological members of the project and ultimately led to the decision to relegate the chemical oceanography datasets (e.g., metabolomics and lipidomics) to ancillary data status reshaping the entire project to make transcriptomics data more of the focal point for both the analysis and overall narrative that would go into a publication.

In the example described above, we can see how the research direction shifted significantly from being on the side of data science to one more focused on biological oceanography questions. Sustained engagement across multiple research sites made it possible to be present and develop a comprehensive understanding of how researchers' practices, perspectives, and orientations evolved in relation to critical inflection points and events that may have otherwise been missed.

3.4.4 Modes of Engagement and Changing Roles. My extended engagement with this project and its members also resulted in seeing a change in my own role. I initially joined as an observer and on occasion would be requested to participate by sharing feedback on ways to improve how the project was being organized. For instance, I shared some examples of project documentation templates that I observed being employed by other labs but not on the data integration project. On another occasion, I shared some publications on the topics of data work and problem formulation in data science. Through making these small contributions my role on the project would continue to evolve to being what the project lead termed as the "collaboration consultant" on the team where I would be requested to help provide information and guidance on managing such matters.

In turn, this made it possible to build deep relationships with members on the project, fostering trust and understanding, which opened doors to richer data and more candid insights that might not be readily available. Many of the researchers felt more comfortable expressing their frustrations in regards to feeling like they were at a stalemate when it came to what exactly they were studying and how exactly their datasets could be made complementary. Different members of the collaboration had expertise in different potential components of an analysis, and nobody had expertise about how these pieces should come together. Obtaining such insights would not have been possible if I was just a silent observer. There is only so much you can learn about a project and its members while sitting to the side.

Conducting extended multi-sited investigations is useful for developing comprehensive insights into how new phenomena and research directions are constituted in relation to the formation of research problems and data integration. It places special analytical focus on the changing practices, perspectives, and experiences of participants, particularly as they relate to critical inflection points or junctures in the research project. Sustained engagement across multiple sites also makes it possible for us to track how

researchers' accumulated experiences shape their collective understanding, decision-making processes, subsequent actions, and the implications this has on the research project as a whole.

4 Our Concluding Remarks

Infrastructural systems are sometimes invoked as partial answers, or aspirationally, as full answers to wicked problems. However, the development of such systems is fraught with its own forms of contestation and internal complexity, and the thousands of footprints of many stakeholders and organizations. Such endeavors are in need of analysis and support that could yet be provided by HCI and CSCW. There is a "squishy middle" between formalized network models that act on simple metrics, such as citation analysis or expenditures, and ephemeral dialogic sensemaking [30]. The latter is where, after coming to the table, stakeholders decide what the table itself should be, and how it can actually live in the world. Depending on what field you come through, you might think of this as conceptual design, problem formation, or even hypothesis generation. We hope that these essays will provide stimulation for further discussions in HCI, as we look to the future for new ways to engage and grapple with the entanglements presented by problems that are technically, materially, and socially complicated.

The extended view–wide coverage across teams/organizations and long term–is a critical element of our research. It is a critical component because it allows us to grapple with issues of scaling, organizational complexity, and how design/problem spaces intersect and evolve. We look at these extended phenomena, not for the particular purpose of theorizing the long-term or capturing specific eras, although we may do so. Our greater purpose, similar to work by others [3, 4, 18, 19], is to follow how particular events and interactions can percolate and spur development, or cause desiccation, in other parts of a sociotechnical system. Eventually, these "percolations" can reshape the "system" and furthermore reshape, shore up, or eradicate parts of the larger network of people, processes, and material: the "ecosystem". If we can understand these dynamics better, these understandings may enable opportunities for strategic, local design interventions.

Most of our lab's studies began in a typical way for our field, focusing on a particular project to develop a particular system, and associated standards, but over time the studies came to center on how collaborative dynamics shifted not only the scope and functionality of the intended design product, but also affected programmatic and infrastructural level changes. For example, products could multiply, new practices and processes could be established, or new opportunities could be identified and then vigorously pursued. In order to get enough details to get analytic traction, sometimes we must dive deeply into the minutiae of science, engineering, or computation.

Our research has sometimes pivoted to questions of how networked ecosystems of people and organizations affect sociotechnical change. In the late 90s and early 2000s, infrastructural research was focused on studies of "cyberinfrastructure" projects that were designed to support specific research programs. These systems were sometimes colloquially described as "systems of systems," but what a sociotechnical system of systems actually was, never mind how one worked, remained an open question [16]. What "systems of systems" meant for HCI and CSCW design researchers and practitioners was then even farther out of view. Progress is being made, but we still don't have clear answers.

Researchers like ourselves are working towards a better understanding of collaborative interactional dynamics across and within scales. How do we understand them? How do we intervene as designers, developers, managers, policy makers? How do we take on—with humility, purpose, strategy, and drive—improvements that center the needs of communities of stakeholders that have differing priorities yet wish to build and share infrastructural systems anyway? We'd like to think that we are asking the right questions. What we do know is that our questions are deeply rooted.

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References

[1] Philip E Agre. 1999. Designing the new information services. *Educom Review* 34, 5 (1999), 12–14.
[2] Anne Beaulieu. 2010. Research Note: From co-location to co-presence: Shifts in the use of ethnography for the study of knowledge. *Social studies of science* 40, 3 (2010), 453–470.
[3] Matthew J Bietz, Eric PS Baumer, and Charlotte P Lee. 2010. Synergizing in cyberinfrastructure development. *Computer Supported Cooperative Work (CSCW)* 19 (2010), 245–281.
[4] Susanne Bødker, Christian Dindler, and Ole Sejer Iversen. 2017. Tying knots: Participatory infrastructuring at work. *Computer Supported Cooperative Work (CSCW)* 26 (2017), 245–273.
[5] Michael Burawoy. 1998. The extended case method. *Sociological theory* 16, 1 (1998), 4–33.
[6] Paul Dourish. 2001. *Where the action is.* MIT press Cambridge.
[7] Paul N Edwards, Geoffrey C Bowker, Steven J Jackson, and Robin Williams. 2009. Introduction: an agenda for infrastructure studies. *Journal of the association for information systems* 10, 5 (2009), 6.
[8] Yrjo Engestrom. 2000. Activity theory as a framework for analyzing and redesigning work. *Ergonomics* 43, 7 (2000), 960–974.
[9] Elihu M Gerson. 2008. Reach, bracket, and the limits of rationalized coordination: Some challenges for CSCW. *Resources, co-evolution and artifacts* (2008), 193–220.
[10] Akhil Gupta and James Ferguson. 1997. *Anthropological locations: Boundaries and grounds of a field science.* Univ of California Press.
[11] Helena Karasti, Karen S Baker, and Eija Halkola. 2006. Enriching the notion of data curation in e-science: data managing and information infrastructuring in the long term ecological research (LTER) network. *Computer Supported Cooperative Work (CSCW)* 15 (2006), 321–358.
[12] Helena Karasti and Jeanette Blomberg. 2018. Studying infrastructuring ethnographically. *Computer Supported Cooperative Work (CSCW)* 27 (2018), 233–265.
[13] Bruno Latour. 1987. *Science in action: How to follow scientists and engineers through society.* Harvard university press.
[14] John Law. 2004. *After method: Mess in social science research.* Routledge.
[15] Charlotte P Lee, Paul Dourish, and Gloria Mark. 2006. The human infrastructure of cyberinfrastructure. In *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work.* 483–492.
[16] Charlotte P Lee and Kjeld Schmidt. 2017. A bridge too far? *Critical remarks on the concept of'infrastructure'in CSCW and IS. I V. Wulf., V. Pipek., D. Randall., & M. Rohde (Red.), Socio-Informatics: A Practice-based Perspective on the Design and Use of IT Artifacts* (2017), 177–218.

[17] George E Marcus. 1995. Ethnography in/of the world system: The emergence of multi-sited ethnography. *Annual review of anthropology* 24, 1 (1995), 95–117.
[18] Drew Paine and Charlotte P Lee. 2020. Coordinative entities: Forms of organizing in data intensive science. *Computer Supported Cooperative Work (CSCW)* 29 (2020), 335–380.
[19] Volkmar Pipek and Volker Wulf. 2009. Infrastructuring: Toward an integrated perspective on the design and use of information technology. *Journal of the Association for Information Systems* 10, 5 (2009), 1.
[20] David Ribes. 2014. Ethnography of scaling, or, how to a fit a national research infrastructure in the room. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*. 158–170.
[21] David Ribes and Thomas Finholt. 2009. The Long Now of Technology Infrastructure: Articulating Tensions in Development. *Journal of the Association for Information Systems* 10, 5 (2009), 375–398.
[22] Janet Roitman. 2020. *Anti-crisis*. Duke University Press.
[23] Kjeld Schmidt and Carla Simonee. 1996. Coordination mechanisms: Towards a conceptual foundation of CSCW systems design. *Computer Supported Cooperative Work (CSCW)* 5 (1996), 155–200.
[24] Susan Leigh Star and Karen Ruhleder. 1996. Steps toward an ecology of infrastructure: Design and access for large information spaces. *Information systems research* 7, 1 (1996), 111–134.
[25] Stephanie B Steinhardt and Steven J Jackson. 2014. Reconciling rhythms: plans and temporal alignment in collaborative scientific work. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*. 134–145.
[26] Anselm Strauss. 1985. Work and the division of labor. *Sociological quarterly* 26, 1 (1985), 1–19.
[27] Anselm Strauss. 1988. The articulation of project work: An organizational process. *Sociological Quarterly* 29, 2 (1988), 163–178.
[28] Joan Tronto. 2020. *Moral boundaries: A political argument for an ethic of care*. Routledge.
[29] Diane Vaughan. 2004. Theorizing disaster: Analogy, historical ethnography, and the Challenger accident. *Ethnography* 5, 3 (2004), 315–347.
[30] Karl E Weick and Karl E Weick. 1995. *Sensemaking in organizations*. Vol. 3. Sage publications Thousand Oaks, CA.
[31] Robin Williams and Neil Pollock. 2009. Beyond the ERP implementation study: a new approach to the study of packaged information systems: the biography of artifacts framework. *ICIS 2009 Proceedings* (2009), 6.

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