Prototypes as Objects of Desire

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ABSTRACT
We set out to explore the role of prototypes as instruments of knowledge for HCI research. We pursue an epistemological inquiry on ‘how’ prototypes can be used when users, designers and researchers work in common on the development of future technological objects. First, we offer critical commentary on prototypes as instruments of knowledge by engaging with existing literature. Under-explored themes are developed to argue for approaching prototypes as objects of desire. Desires are different from needs and requirements and ought to be considered more directly in research prototyping processes. We identify five roles for prototypes as objects of desire for research and articulate four seeding dynamics that govern exploration of future use. These are exemplified through analysis of two cases where groups of people were working in common around designing interactive objects. We conclude that prototypes as objects of desire allow exploration of ‘yet-to-be-known’ shared technology beyond needs and requirements.

Author Keywords
prototypes, prototyping, desire, common artifacts, future use, seeding dynamics

CCS Concepts
•Human-centered computing → Collaborative interaction; Interface design prototyping;

INTRODUCTION
Prototypes have long been recognized as an important instrument for research and design of technologies. Yet, our understanding of what prototypes do with respect to HCI research processes remains under-explored. This work was born out of authors’ frustrations and needs as researchers in the Common Interactive Objects (CIO) project. CIO combines empirical, analytical, theoretical, and design approaches with the goal of empowering users to better understand and develop the technologies they use [17]. While we did find value in engaging with existing research on prototypes, we also felt a distinct lack of conceptual handles for describing, analyzing, and generating future possibilities that unfold through prototypes. In this work, we explore the role of prototypes specifically with respect to research on how people work in common around interactive objects and future use. This means that we concern ourselves with: (a) research and design processes where researchers, designers and users collaborate through prototyping and collaboratively develop prototypes, and (b) use cases that are focused on common, shared or collaborative use of interactive technological objects. But why is this relevant?

Based on literature from the 1980s, we know that prototypes are important as a means of engaging future users in relating to their future technologies [7, 22]. In addition, prototypes play a role not only for practical design, but also in the research processes that are carried out in HCI, where the purpose is to explore and understand future forms of human-computer interaction, as much as it is to build products. Therefore, it is important and necessary to gain conceptual clarity about the role of prototypes as an instrument of knowledge for research. We are specifically interested in ‘how’ prototypes can be used for research when studying people who are collaboratively designing for and working in common around interactive objects and future use. We build upon existing notions such as common artifacts [52] and common information spaces [6] to explore the role of prototypes for HCI research on future use.

In this paper, we pursue an epistemological frame of inquiry by focusing on ‘how’ prototypes inform current practices and hint towards what might be possible (in contrast to an ontological frame of inquiry that aims to answer ‘What is a prototype?’). We offer our work as a complementary perspective alongside existing works on prototyping such as Lim et al.’s work on the anatomy of prototypes [41] and carry forth insights from efforts such as Co-operative prototyping [9]. We set out to explore and develop conceptual clarity through our research question: How do prototypes inform current practices and future use in research involving people who work in common around interactive objects? Specifically, we present our work as a critical attempt investigating:

1. various ways prototypes come into being with respect to HCI research processes;
2. under-explored themes on how prototypes inform current practices and future outcomes; and
3. how ‘else’ can we think about prototypes for research involving people working in common around interactive objects?

In our work, we approach prototypes as mediating the design activity at large, be this for users, designers or researchers, in different activities and with different other means of de-
sign. Prototypes are crossing boundaries between activities and practices, as something that point ahead towards future use, yet also as something that is material, provides hands-on experience and resists their own re-shaping. Exploring such tensions, we pursue our research question through two related analytical strategies to better understand the structural and functional aspects of how prototypes inform future outcomes. First, we engage with existing literature and offer critical commentary on scoped themes discussing the role of prototypes as instruments of knowledge for research under the Section ‘What are prototypes for?’. We engage with heterogeneous views on prototypes in order to trace relevant themes, highlight tensions, identify research gaps, and conceptually develop under-explored ideas on how prototypes inform current practices as well as future use.

Robinson notes that “insights into the possible (i.e. imagination) need to be used in conjunction with functional analysis” [52, italics original] when designing common use artifacts. We argue that the language of desire is more apt to think and talk about possible futures since what is possible is not always fully knowable in advance through user needs and functional requirements alone. To this effect, we propose prototypes as objects of desire that invoke familiarity with past practices while simultaneously piquing our curiosity about possibilities for shared technology mediated futures in the ‘Prototypes as Objects of Desire’ Section.

Janlert and Stolterman point out that “each interactive situation creates a space of possible actions for the user [wherein the] space of possible actions is the totality of the actions or reactions that are available or possible for a user in relation to the artifact or system” [33, italics original]. We adopt the notion that “action, taken in the present, preserves the space of experience in a dialectical tension with the horizon of expectation” [50] and posit that a desire based conceptualization of prototyping and prototypes can allow researchers to grasp and articulate such ‘dialectical tension’ better. We agree with Nelson and Stolterman [46] about considering in design what they call desiderata, or desired things as not only rational requirements and needs. Our aspiration in the current paper is to move even further beyond intention. Approaching prototypes as objects of desire can allow researchers to conceptually grasp how current actions build upon past practices and explore together what is ‘yet-to-be-known’ as possible technology mediated future outcomes.

While conventional approaches such as requirement specification may work efficiently for well-defined user tasks, research on common artifacts necessarily involves engaging with unanticipated use. The fundamental prototyping principle focuses on “finding the manifestation that in its simplest form, filters the qualities in which designers are interested” [41]. In order to conceptually engage with unanticipated use and explore possible future outcomes for HCI research, we identify four seeding dynamics, each offering an analytical focus. Giacardini describes seeding as “a participatory and evolutionary technique that allows the modification of a system and its adaptation to users’ emerging needs” from a metadesign theoretical perspective [25]. In our work, we conceptualize four seeding dynamics to understand how desire unfolds and informs possible futures through the design and use of prototypes by user groups, designers, and researchers. Each seeding dynamic foregrounds a conceptual focal point for understanding and developing prototypes as objects of desire in the context of research on common artifacts. Accordingly, we elaborate on research processes, use contexts, spatio-temporal arrangements, and boundaries involved in prototyping and exemplify them by analyzing two cases where groups of people were working in common around designing interactive objects.

Our contributions include: critical commentary on the use of prototypes as instruments of knowledge; explicating under-explored themes on ‘how’ prototypes inform current practices and future outcomes; conceptual re-alignment and argumentative justification for approaching prototypes as objects of desire; articulation of five roles prototypes perform as objects of desire for research; illustration of four seeding dynamics by analyzing two empirical cases to understand how desire unfolds and informs possible futures through prototypes. We do not aim for a systematic review of literature on prototypes or a universal framework for prototyping.

WHAT ARE PROTOTYPES FOR?

Since the 1980s prototypes have played an important role in HCI and the basic principles of prototyping (iteration and interactive/running prototypes that can be explored by users and designers) have made their way into standard textbooks, e.g. [3], and become parts of ISO standards. While it is widely acknowledged that prototypes play an important role in design, there is less clarity about what prototypes are, ought to do and connect to one another with respect to research processes in HCI. In an effort to address such concerns, we aim to explore the various ways prototypes come into being with respect to HCI research studying people working in common around interactive objects and future use. In this section, we engage with existing literature and offer critical commentary on scoped themes concerning the use of prototypes as instruments of knowledge for research studying people working in common around interactive objects and future use.

Prototypes as Research Instruments

Exploring the anatomy of prototypes, Lim et al. propose a framework for prototype conceptualization “enabling designers to reflect on their design activities in exploring a design space” [41]. We position our work as a complementary perspective to [41] and focus on the role of prototypes as instruments of knowledge for research. Broadly speaking, research instruments are constructed to observe phenomena of interest and provide a system of inferences that allow researchers to assign meaning and value to their findings. Research instruments introduce shared structured procedures for making observations and claiming inferences that are discursively anchored in existing research practices and theories. If we are to consider prototypes as instruments of knowledge, then it behooves us to explore the role and value of prototypes for research.

Greenberg and Buxton articulate an important dilemma for HCI research: “How can we create what could become culturally significant systems if we demand that the system be vali-
dated before a culture is formed around it?” [26]. Prototypes as instruments of knowledge allow researchers to generatively explore future use scenarios without having to circumscribe the role of prototypes strictly for product development purposes only. Approached from a ‘Research through Design’ (RtD) perspective, Stappers points out that prototypes can be used to test a hypothesis, confront theories, concretize abstractions, and make interventions while doing research [57]. Koskinen and Frens draw distinctions between design prototypes, industrial prototypes, and research prototypes, each with a specific focus. The “purpose of research prototypes is to articulate and test concepts that respond to questions from theoretical literature at the bottom or a research program rather than product development” [37]. Let us unpack how prototypes function as research instruments for exploring theory guided inquiry into future outcomes beyond product development.

Prototypes as instruments of knowledge can be thought of as embedded artifacts in a theory guided inquiry. Prototypes are not merely proof-of-concepts of a particular idea for research but serve as “working capital, the indispensable resources of further inquiry of finding out or learning more things” [21]. Prototypes, when considered as ‘working capital’ for research, then can be said to contribute towards intermediate level knowledge i.e. “knowledge that is more abstracted than particular instances, yet does not aspire to the generality of a theory” [31]. Thus, prototypes as research instruments can be said to represent particular instantiations of concepts/ideas/theories while simultaneously acting as ‘working capital’ for evolving research processes/questions/insights beyond the artifact.

Odom et al. point out that people’s engagement with prototypes is predicated on ‘what it might become’ i.e. “prototypes are placeholders for something else; they are an instantiation of a future outcome” [48]. Drawing upon Participatory Design literature, Korsgaard et al. [36] see prototypes as computational alternatives in research. They discuss how prototypes are generative and point ahead: When a prototype serves as a computational alternative it raises questions, and makes us see what exists in a new light. A computational alternative is not designed to showcase a new technical solution to a well-known problem, but to elucidate problems in the otherwise taken for granted. Prototypes when considered as computational alternatives provide disruptive (as opposed to incremental) evidence for research since they are intended to question, provoke, and reorder existing discursive gestalt on a specific research focus. Here we point to two ideas relevant to the disruptive potential of prototypes for research: Wartofsky’s tertiary artifacts [60] and Engeström’s springboards [23].

Building on the work of Wartofsky, Bertelsen describes tertiary artifacts as “a basic concept in understanding creativity and innovation as a material phenomenon that mediate imagination or conception of new motives/needs as radical alternatives to the well-known” [5]. Tertiary artifacts serve as inspirations and provocations that are transplanted from a different context with the goal of exploring alternatives to already established ways of thinking. Tertiary artifacts “change productive praxis by changing the established modes of perception” [5]. In representing possible futures to participants and researchers, prototypes can serve as springboards wherein a “springboard is a facilitative image, technique or socio-conversational constellation misplaced or transplanted from some previous context into a new” [23]. Exploring the role of artifacts in the contextualization of actions, Bødker and Christiansen point out that when using springboards, the “reference point is no longer the immediately known presence, but the activity under expansion” [8]. Wartofsky’s tertiary artifacts [60] and Engeström’s springboards [23] highlight creativity facilitated through the introduction of an unexpected artifact into future use contexts.

To quickly recap, prototypes as research instruments:

- introduce a shared structured procedure for making observations and claiming inferences
- contribute towards intermediate level knowledge by representing particular instantiation of ideas and theories while simultaneously acting as working capital for evolving research processes and questions
- can serve as disruptive evidence that can be used to question, provoke, and reorder existing discursive gestalt on a specific research focus

Prototyping as Mode of Inquiry

Different prototyping techniques can be said to enable different modes of inquiry with varied intentions and outcomes. We adopt a critical attitude by asking ‘how’ prototypes are used, by whom, and towards what ends. Floyd did some of the early work on identifying types of prototyping that one finds in software development (explorative, experimental prototyping and versioning/evolution) [24]. When prototypes are used for exploration, they are used to clarify requirements and desirable features, and to discuss alternative possibilities. Prototyping for experimentation can be done to determine adequacy of solution before large-scale implementation. Prototyping for evolution is a process that can go on beyond the normal temporal boundaries of the design process and is focused on adapting the system to gradually and continually change. While the above three categories are not exhaustive, Floyd’s work demonstrates how prototypes: (a) can serve multiple purposes; (b) are structurally and functionally aligned in accordance with specific processes (e.g. requirements gathering, versioning, etc.), and; (c) make possible specific actions (and by extension refrain others) for different actors in various settings. Floyd astutely warns that by using terms such as “to play with” while using prototypes, prototyping as an activity may “conceal that this type of user involvement can be a sophisticated way of tuning the system contrary to the users’ interest” [24].

Addressing recent developments in social computing, Grevet et al. argue that “traditional HCI prototyping techniques do not translate well to large social computing systems” and propose piggyback prototyping, a six stage process that is formulated to “focus on what people do on a social computing system rather than how to attract people to the system” [27]. Desjardins et al. present their insights on prototypes from the perspective of a “maker/user in a space rather than with artifacts in isolation” and identify prototype qualities in reconfigured space [20]. Each of these approaches afford different conceptions of prototypes and shift focus on what prototypes are for. Different prototyping approaches allow us to ask different sets of
questions, foreground different sets of concerns, and enable different sets of actions as future possibilities. Therefore, a prototyping approach can serve as a mode of inquiry with specific justificatory potential for research.

As Sol argues, “prototyping is not only related to concrete model systems, but also to abstract ones” [56]. Further, prototypes facilitate mutual learning wherein users explore future use and researchers can learn about users’ work practices. Bødker et al. [9] approach prototyping as ‘an on-going learning process’ and analyze situations where openings for learning occur in the prototyping activity, including such that simulate the future work activity through prototyping, where prototypes are manipulated and used as a basis for idea exploration and specifically looking towards the future, or as prototypes challenging the present, as Mogensen frames them [44]. Krogh et al. identify five forms of design experiments in research-through-design and propose a typology that “accounts both for relations between major cases and iterations embodied in detailed sketches and prototypes” [38]. Even though prototypes have been acknowledged as important in design, we believe more scholarship is needed on how different prototyping techniques facilitate different modes of inquiry for research exploring technology mediated future possibilities.

Prototypicality and Praxis
Prototypes can be used to bring together users, designers, researchers, and other relevant participants each with different qualifications, roles, experiences, and expectations. Houde and Hill point out that prototypes “provide the means for examining design problems and evaluating solutions” [32]. Bødker introduces an Activity Theory inspired approach to the design of user interfaces [7] in order to better engage with the emergent complexity (in contrast to predetermined task routines) of use, support situated sense-making, and understand technology mediated actions. Emphasizing the social nature of human actions, Bødker foregrounds the Why, What, and How questions in order to understand the motivations, goals, and operations involved in technology mediated interactions between people. Suchman et al. argue from an ethnomethodological perspective that prototypes are “designed to effect alignment between the multiple interests and working practices of technology research and development, and sites of technologies-in-use” [59]. What remains unclear is how praxis evolves over time among people and how to study these processes through the use of prototypes for research. Grønbæk identifies three scenarios [28] that point to different levels and aims of user interactions with prototypes:
- ‘prototypes that become the system’ approaches where prototypes are used “primarily for the users to adjust details of the system”
- ‘executable specification’ approaches where prototypes are used “to obtain a full, formal specification of (parts of) the future system behavior”
- exploratory approaches where prototypes “serve mainly as a means for idea exploration before they are turned into a specification of the application to be developed”

While designing with users in a cooperative setting, Bødker argues that the goal of prototyping activity “is different from that of the use activity: to gain experiences about the computer application for the purposes of further design, as opposed to the actual conduction of the work” [7]. Actively engaging users in the design processes, Bødker and Grønbæk set out to define in particular what they call Cooperative prototyping. They emphasize active involvement of users in the design process as co-creators with skills that are different than designers. Further, cooperative prototypes facilitate material dialog between users and designers for eliciting requirements and evaluating solutions, facilitating concrete discussion of visions [10, 29]. In this, they emphasize that it is the responsibility of the designers to build prototypes in such a way they become objects for a shared purpose. Prototypes can be used in research to explore alternatives with the aim of reflexively informing existing praxis.

Prototypes inform and mediate praxis; yet there is a wanting of both theoretical and empirical research on how this happens over a period of time. Put another way, prototypes are unique as instruments of knowledge for research concerning how past practices can inform present actions that are oriented towards specific visions for future. Perhaps due to market driven innovation cycles that prioritize ‘quick-and-dirty’ prototyping approaches for user evaluation towards a product/system/service, there seem to be less research scholarship on how praxis evolves over a period of time among a group of people through the use of prototypes.

Prototypes as Epistemic Objects
In CSCW at large, the notion of boundary object [58] has often been used to understand the way human beings organize their practices and collaborate around objects. Prototypes can, and have been, analyzed as boundary objects, and as syntonic seeds [61] that move back and forth between being instruments and objects of activity, working locally in many activities while also embracing contradictions between the local needs. However, prototypes are in essence pointing to practices and uses that do not yet exist, and this perspective points towards Nicolini et al.’s exploration of both boundary objects and Knorr Cetina’s epistemic things [47, 16]. According to this summary, epistemic objects provide the direction, motivation and meaning for the activity, following Leontjev [40, 39]. They are emergent, fragmented, and constantly expanding [23, 43]. Objects are instruments of translation (boundary objects) and sources of attraction (epistemic objects, and triggers of contradictions and negotiation. Objects are also boring and everyday scaffolding of human activity.

“Objects becomes epistemic when they embody what one does not yet know. Because of this open ended nature, they acquire a deep emotional holding power and generate intimate attachment which creates social bonds, either because their complexity requires joining forces, or because the drive and desire towards the same object constitutes the basis for mutual recognition and sense of belonging” [47, p. 8]

Nicolini et al. summarize epistemic objects to foreground the power of material objects (and not only visions and ideas). Epistemic objects embody what one does not yet know. Knorr Cetina [16] talks about how such objects creates attachment
that also, paradoxically, points out the incompleteness of the objects. Epistemic objects introduces a collective obligation towards the participants beyond the individual. They are opened and work as a source of interest and motivation by virtue of their opacity and their material transcendence, which we find particularly apt when thinking about prototypes. Prototypes are not developed and used by individuals one at the time and hence it is interesting to study further how, as epistemic object, they operate ‘as the engine of solidarity among groups’ [47] when the wanting the epistemic object generates, keep together the collaborators around it. Following [43], collaborative activity is maintained around the pursuit of a partially shared, partially fragmented, and partially disputed objects. Further research is required to explore how prototypes are emergent and incomplete, the wanting they create, the fragmentation and how they are disputed among people working in common around interactive objects.

Under-explored Themes
Research arguments in HCI do not merely report findings but contribute by making recommendations for/against a specific set of future actions. Exploring epistemic and methodological plurality in doing HCI research, Olson and Kellogg frame “design as a way of knowing in which designers would push the boundaries of what is introduced in the world in order to find out more about the world” [49]. Doing research in HCI involves engaging with the present state of affairs as dialectically rooted in the past while simultaneously exploring what might be possible for the future. In this subsection, we will identify and articulate themes that are currently under-explored with respect to how prototypes inform current practices and future outcomes for research.

Traveling prototypes
As noted earlier, there is a dearth of scholarship in HCI on how praxis evolves through the use of prototypes over a period of time among a group of people. Meaningful evaluation of designed artifacts and their use requires an understanding of the context of their deployment. Therefore, there is a necessity to study how prototypes are packaged to travel across various contexts such as lab studies, demos, hackathons, and curated collections. Further, prototypes are seldom stand-alone artifacts in terms of their use and often times introduced into an ecology of existing devices and practices. Studying how prototypes travel across time and space can help researchers to understand the broader impacts of their design intervention within existing settings.

Curating failure
Prototypes are not always working models but often times serve as material proof of failure and empirical evidence against a specific idea. With the exception of a few works such as [4, 45, 1], failure remains mostly unreported in HCI for various reasons such as “avoiding the perception that something is wrong with our research methodology” [15]. The existing norm of reporting research in HCI mostly involves working prototype iterations which leads us to a pragmatic question: what is the value of failed prototypes for research and how to curate them?

Prototyping the past
While prototypes have been studied for ‘future use’ or as ‘first of its kind’ objects, we believe that prototypes can and should be used to study practices and processes that are constitutive of the present in terms of the past. Prototypes from past should be studied through an archaeological lens of understanding the practices and processes that are believed to have led to the contingent present. Sayers proposes ‘prototyping the past’ as a methodology to understand “how and why technologies matter by approaching them as representations and agents of history” [54] and argues that such an approach “offers a complement to speculative design in medium and thought” [55]. Studying prototypes as historically contingent objects can help us challenge dominant narratives and existing tropes that may remain unquestioned otherwise.

Prototyping and performativity
Prototypes are not merely instrumental but also act as performative objects wherein “one’s identity emerges through various actions performed, and the resulting experiences” [34]. Studying disease management technology, Danholt articulates prototypes as “material things that prescribe, animate and produce bodies and agencies... in order to understand the mutually transformative consequences for both artifacts and humans in these processes” [18]. Exploring designing with disabled people, Bennett et al. propose the notion of ‘Biographical prototypes’ as “material manifestations of people’s oral or written personal stories of ‘making something work.’” that act as “openings for elevating forgotten, untold, and uncredited design contributions” [2]. Both these examples highlight an often over-looked but important aspect of how prototypes can become objects that have “deep emotional holding power and generate intimate attachment” [47]. Therefore, it is vital to pay attention to the performative aspects of prototypes and prototyping for research.

PROTOTYPES AS OBJECTS OF DESIRE
By engaging with existing literature, we have articulated how prototypes can serve as shared design objects that make it possible for multiple, and at times conflicting, goals, visions, and outcomes involving different groups of people to unfold through technology mediated interactions. In this section, we posit that conceptualizing prototypes as objects of desire can allow researchers to better articulate and understand the role of prototypes for exploring what is possible as shared futures mediated through technological interactions. We use the term desire as a descriptor for prototypes to denote the attachment and curiosity they incite to something in the future that is “destined to remain partially unfulfilled” [47]. Prototypes as objects of desire does not necessarily imply that the objects themselves are desirable or produce desirable outcomes. We propose ‘prototypes as objects of desire’ as a conceptual realignment that foregrounds the relationship between people and objects in terms of desire.

Why Desire?
Studying people working in common around interactive objects involves paying attention to complex temporal arrangements, shared material resources, networked decision making processes, distributed systems across multimodal devices,
value tensions, labor divisions, competing agendas, and hierarchical power relational scenarios, among others. Further, “creation of technology requires not only scientific knowledge but craft knowledge and phronesis (the setting of values)—a political rather than scientific act” [30, italics original]. When we approach design as an endeavor to intentionally change existing state of affairs, hopefully towards the better, it is crucial for HCI researchers to be able to conceptually apprehend, articulate through words, and act upon our collective desires towards a better future. In other words, design-based HCI research requires conceptualization, articulation, realization, and justification of specific desires over others.

Kaye argues that while doing research in HCI “there is a deliberate causality: forward-looking statements in HCI papers do not just predict the future, but attempt to make it happen” [35, p 27]. Approaching prototypes as objects of desire can allow HCI researchers to explore the interplay of desiring (such as wanting, yearning, longing, craving, etc) and the possibilities for desirable futures through design. To speak of prototypes as objects of desire for research necessitates attending to the motivations, intentions, intensities, means, investments, conflicts, identities, and rewards associated with specific desires and their corresponding action possibilities for future.

Desiring Mechanisms and Prototypes
Prototypes lend desiring mechanisms through which actions in the present build upon past experiences while simultaneously enabling exploration of what might be possible in the ‘yet-to-be-known’ future. As Markussen puts it, “a horizon of expectation of the future implies a certain way of thinking about the past” and “ideas about the future, horizons of expectation are shaped around the prototype; the participants interpret problems in the present in this perspective” [42]. Desiring mechanisms are concretized through prototypes and shape metaphoric and metonymic relations that structure the present in relation to past and future. Reciprocally, prototypes may be regarded as instances of stylized desiring mechanisms with specific filters and manifestations [41] that generate curiosity, attachment, and social bonds.

Metaphoric relations are structured based on similarities and involves two or more conceptual domains at the same time such as multiple prototypes exploring a specific problem framing. Metonymic relations are based on contiguity and association within a specific conceptual domain such as the evolution of an idea through iterative prototyping. Prototypes lend desiring mechanisms by which actions in the present are: (a) made sense of by exploiting familiarity with past experiences i.e. metaphoric relations that allow us to select and substitute similarities from a range of available alternatives, and (b) directed towards exploring what might be possible in the ‘yet-to-be-known’ future as deliberate causality i.e. metonymic relations that structure and link the past, present, and future.

Presencing Absence
We will elaborate on a particular desiring mechanism we call presencing absence. Prototypes can be used in research to account for an absence or lack in the present thereby justifying creation of specific futures as desirable. The presencing absence desiring mechanism aims to call attention to what is currently rendered invisible and muted out of context as irrelevant within existing problem framings. For instance, the feminist makerspace Prototype PGH has a mission “to build gender and racial equity in tech and entrepreneurship by providing affordable access to high tech tools and equipment, offering workshops that center the experiences of women and underestimated communities, and cultivating a professional support network” [51]. In order to articulate what is present/relevant and yet absent/muted currently in existing discourse (such as awareness of gender and racial inequities), it is necessary to explore and experience absence in terms of material relations and shared practices.

From a co-design perspective, “designers and non-designers working together, using making as a way to make sense of the future [wherein] the thing being made is not a forerunner of the future product, but a vehicle for observation, reflection, interpretation, discussion and expression” [53]. Prototypes and prototyping allow participants to experience what is missing in the present, invoke desires about what is possible, and support consensus building towards shared technology mediated futures. The presencing absence desiring mechanism when concretized through prototypes can facilitate researchers to: (a) account for systematically marginalized concerns in the past, and (b) persuade collective actions towards specific alternatives as desirable futures.

Role of Prototypes as Objects of Desire
Based on the discussion so far, we identify five important roles that prototypes perform as objects of desire for research.

1. Despite being epistemic and not-yet-known, prototypes manifest shared visions to be scrutinized and negotiated jointly by participants in the research-prototyping process.
2. Prototypes are also manifestations through which multiple visions may be juxtaposed, contrasted and explored enabling critical reflection on existing research framings and practices.
3. Prototypes allow for a dynamic reiteration of visions (objects of desire) on the background of other visions (objects of desire), hence whether ultimately there is a shared wanting among participants or not, the research-prototyping process will/may change these.
4. Prototypes can become icons as material evidence and lend force to research arguments thereby setting standards for what is desirable.
5. Prototypes can provide disruptive justification that questions existing norms by accounting for what is missing by presencing absence in order to collectively bring desirable changes in the future.

EXAMPLE CASES
We illustrate our conceptual thinking with two empirical studies, CaseLine and Local Area Artwork (LAA). These two research projects chosen are instances of prototyping processes in use cases where people were working in common around interactive objects and are analyzed based mainly on available literature. One of the authors, Bodker, was involved as a
researcher in both CaseLine and Local Area Artwork (LAA) projects. We exemplify these two cases through the four seeding dynamics to shed light on how prototypes act as objects of desire that inform current practices and make it possible to explore together what is ‘yet-to-be-known’ as future. These seeding dynamics provide conceptual focal points for understanding and developing prototypes as objects of desire in the context of research on common artifacts.

**CaseLine**
CaseLine is a web-based tool used primarily for collaboration between citizens and municipal case workers with respect to the Danish parental leave legislation. The project also involves other relevant participants such as employers of parents and their labor unions.

**Local Area Artwork (LAA)**
LAA was a design prototype set up to explore location-based art curation in a setting involving art curators, artists and audience in a local art gallery. The starting point was a wish from gallery curators to explore more democratic forms of art curation, and from researchers to explore the potential of location-based services [11].

**Research Process Dynamics**
Under the theme of research process dynamics, we explore the research settings, processes involved, and epistemic orientation to better understand how the prototypes were developed and the context of their deployment as instruments of knowledge for research. For CaseLine, researchers with background in HCI used participatory design to work with parents and municipal caseworkers as part of project eGov+, which explored e-governance services and infrastructure. Various versions of prototypes for CaseLine were designed based on participatory design processes with both parents and municipal caseworkers. Field studies in three municipal offices were carried out, including workshops focusing on work and document flow. Researchers also did group interviews in established mother’s groups and explored prototypes in seven hours of pluralistic prototype walkthroughs. “In and between these activities, prototypes were developed and altered to capture ideas, progressions, and alternatives” [13].

For Local Area Artwork (LAA) researchers with backgrounds in HCI, art institutions, and art history collaborated in the project, and hence in the shaping of the design experiment for the concrete setting. The design process had a specific agenda of a series of design ideas relating to participation and locality that researchers wanted to explore in the field. The process included a number of meetings, workshops, and ad-hoc communications with staff and artists. These meetings served, e.g., to align the set-up with the practical constraints and aesthetic requirements of the institution and artists as well as with the overall visiting experience. Art gallery visitors were only marginally involved in the design process at large, except for when the running prototype was trialed in the art gallery for a month. Gallery visitors were encouraged to participate in using the prototype.

LAA was founded on a vision of democratic curation, that was shared by curators, and researchers. The trial use of LAA with the gallery visitors however also demonstrated that the curator was largely hidden and not recognized by the visitors, and hence they mentioned how the LAA was or would/could be facilitating discussions with the artists, and hence a new active role for artists in the exhibition. In addition, the visitors were using LAA and discussing it more in the space between communicating between those you looking at the art with, and those coming to see the art piece after you. The phone was, in the eyes of the visitors, part of creating a distance to the immediate group physically together [12]. In this sense it was quite evident that it would make sense to explore some of the basic visions and desires better before putting a running prototype in the exhibition.

The main difference between CaseLine and LAA regarding this dynamic is hence the preparation of the prototype that lead to very different kinds of feedback. In a positive formulation, the LAA prototype when deployed helped raise quite fundamental questions to the use context of desires of the various groups, and actually questions that were rather different from what the researchers had anticipated or even targeted. CaseLine in comparison allowed more concrete exploration of how parents and case workers would be able to collaborate in the future, despite their different desires.

**Use Dynamics**
This dynamic addresses user activities, behaviors of use over time, contexts, motivations, and interactions with others through prototypes. CaseLine was developed as a web-based tool for timeline collaboration between parents and municipal caseworkers in the context of parental leave regulations and employment contracts. CaseLine was to be used by parents to plan their shared leave together and by municipal caseworkers to provide counsel when requested and sanction submitted leave plans. The vision was for CaseLine to support individual parents in imagining and exploring their leave options; parents collaborating across time and space to plan and overview their shared leave plans; for parents to be better able to negotiate leave plans with their employers; and for municipal case workers to better communicate information regarding leave legislation and rules to parents. These visions were all at play in trying out the CaseLine prototype, and the assessment also illustrated tensions between them such as the need for information exposed to employers versus the the information desired from the employers when exploring the options of each parent.

The LAA prototype targeted the art gallery visitors, with a starting point in how curators were interested in more democratic curatorial practices, on the one hand, and a wish of the researchers to develop and explore a Wikipedia inspired curation platform that would be local to the art piece. Hence, the use setting was one where visitors move around an art gallery, alone or together, looking at art and on the curator’s texts on the (typically A4) paper panels next to the art pieces. This text was in the prototype replaced by a one-page interactive text that could be edited by the visitors using a smartphone, but only while they are near the particular art piece (see Figure 1). LAA and its trial use, served a meta-purpose of facilitating the discussion with artists and curators, more than it served
Spatio-temporal Dynamics

We look at how prototypes are both situated within and in turn shape specific spatial arrangements and temporal orderings. Researchers envisioned CaseLine theoretically as a common information space and attempted to understand fragmented exchanges across organizational boundaries. Bohøj et al. argued that “information spaces, such as timelines, should not be understood as where information is stored and retrieved, but where work is done” [13]. Parental leave planning involved careful consideration of parents’ schedules (both as individuals and together), employment contracts, current legal regulations, and financial constraints. Both parents could, in the prototype, make changes to the leave plan and submit it to the municipality through CaseLine. Researchers learned through explorative prototyping that it was essential for parents and caseworkers to be able to work on the leave plan, separately and together as needed during different stages of the process.

CaseLine made it possible for one or both parents to work on the same timeline, synchronously or asynchronously, from one or more computers. Leave plans were shared between parents, negotiated with employers, and officially sanctioned through municipal caseworkers. CaseLine had a sandbox mode for parents to try different leave plan scenarios as per legislation and understand the economic consequences of their choices before finalizing their plans with the municipality. In CaseLine, “parental leave period is a slice of time that needs to be manipulated in planning and decision-making” [13]. Through this temporal ordering, CaseLine made it possible for users to zoom in on specific periods of time against the backdrop of overall timeline with condensed views on either end. The timeline feature assisted users to construct, visualize, explore, and share “what-if” scenarios, hence helping them explore their specific visions for the future.

The LAA project [12] discussed how an art exhibition had many activities happening, including such that shaped the art experience for the visitors. In a curated exhibition, artworks are selected by curators with some kind of idea and sense of quality in mind and the building plays an important role also for their vision. The artists may have produced the art pieces from some sort of idea, some mood or story to convey to spectators, and possibly to impress the curators and hence get selected for the exhibition. There may be a dialogue between the curators and the artists regarding the process and exhibition. The audience, the spectators, gets to see the result, to walk the exhibition, to engage with the artwork, as well as with the curations. Some of the audience may know what the exhibition is about while others don’t. As [12] pointed out: “It is into this network that LAA was presented with the hypothesis that it could extend the engagement among visitors while getting rid of or lessening the authoritative voice of curator in the exhibition, much in the same way as Wikipedia can be seen as a platform for encyclopedia without appointed experts.”

In both cases, prototypes were situated within specific spatial arrangements and temporal orderings, that could however not be taken for granted. The prototypes question space, and in particular collaboration across place around a particular object, be this the parental leave plan of the curatorial text, that were in both cases unknown and in the future. Both prototypes hence manifested temporal orderings and embodied traces of past and current activity with desires for the future. In both cases, the prototypes made it possible to explore and discuss possible, as well as problematic future use.

Boundary Dynamics

Under the theme of boundary dynamics, we study how prototypes are used to create, contest, negotiate, and maintain various boundaries in the context of their use and as instruments of knowledge for research. Regarding CaseLine the participatory design process as such was set up to address the participation of two very different user groups, and one of the boundaries drawn was that the two groups participated separately and not together. With the parents, a further challenge was doing participatory design for infrequent, yet quite intense...
use, as when a new baby arrived and the parental leave needed planning and formalization. In addition, the actual CaseLine prototype was very focused on when access and sharing was open and when information was ‘frozen’ and formalized into a formal plan that could cross boundaries of communities and also be kept for later. CaseLine also opens possibilities of involving and sharing with new groups of users such as friends and family, desires that could be explored more in the continuation of the case.

As illustrated throughout the presentation of the LAA case, several boundaries are in play in this particular case, and with this particular prototyping process. Praxis boundaries between curators, artists and visitors is one such type, and as matter of fact there were even boundary issues in terms of drawing the line between the art piece and the accompanying text. In the prototype evaluation, the visitors presented uncertainty as regards who produced the text on the panel - was it part of the art piece? Could one communicate with the artist? There were not as many parallel concerns relating to the curators, who from the perspective of the art gallery played an important role in setting up the exhibition, and guiding visitors through it. Hence, while the curators are important and authoritative in most art exhibitions, they are also rather anonymous and behind the scene, that in the LAA case was little recognized by the audience. This is ironic of course, since the curators has a strong desire for democratic forms of curation.

In both cases, the prototypes were used to explore and shift various boundaries, both literally in terms of who had access to e.g. be curators, and conceptually in manner of how various communities of users were considering their roles and sharing also in the future. The desires exposed in these processes were in some cases quite strong, and in both cases more the outcome of the prototyping process than the starting point.

**Objects of Desire**

We now exemplify prototypes as objects of desire by returning to how prototypes manifest shared visions and multiple desires that are scrutinized and negotiated jointly by participants in the research-prototyping process. We discuss how prototypes manifest multiple visions that may be juxtaposed, contrasted and explored enabling critical reflection on existing research framings and practices; allow for a dynamic reiteration of objects of desire on the background of other objects of desire; are icons as material evidence and lend force to research arguments thereby setting standards for what is desirable; and can provide disruptive justification for questioning existing norms.

In Caseline we may see the notion of a timeline as shared object, and with that, also a step away from the idea that public administration as in this case is event and document driven [13]. In the case of LAA, the manifestation of the vision of curational text as interactive was manifested in the prototype. We have witnessed this through the actual exploration of the prototypes in the art gallery, the audience form contrasting wishes and desires that are neither aligned with those of the curators, artists or researchers. As we have discussed, these multiplicities could quite likely have been activated even more in the ongoing debate of the overall vision of ‘democratic curation’ among researchers and curators in particular. In the CaseLine example various other mock-ups and prototypes were used to illustrate also e.g. dynamic documents [14]. We have also pointed out various desires when it comes to sharing or not sharing parts of parental leave plans with others.

In LAA, researchers thought of the use of cellphones to interface with the curational text as a practical and flexible way of providing a keyboard to each person. The prototype exploration demonstrated that art gallery visitors were indeed not happy to use their phone and hence to engage with the texts while walking around, rather than engaging with their friends. This questioned the research vision of the (individual) phone as access point to a shared (and possible even more shareable) spectator experience. The examples illustrate how choices made for the research process in many ways impacts the assessment of prototypes when it comes to use. To some extend one may even say they limit the investigation such as when the LAA was (only) assessed with gallery visitors even if the vision of what LAA would do was developed and shared mainly with curators and artists. Or when the needs and visions in the CaseLine were actually going in different directions between parents and caseworkers, and it was up to the researchers to connect the two. These examples also shows that it is important to explore future praxis and physical boundaries more up-front and not take them for granted in neither research nor user-centered design. Research project time duration in some ways were part of this problem, even if longer research projects as such may not have solved it. It seems however that short duration user-centered design processes were not ideally suitable for studying how prototypes inform the future for research, and that hence this element needs to be reconsidered.

**Summarizing the example findings**

Through our exploration and discussion of prototyping material from the two empirical case studies, CaseLine and LAA, we have used the four dynamics and five roles to aid our thinking and illustrate how prototypes come to inform current practices and make it possible to explore together in the research process what is ‘yet-to-be-known’ as desirable or not desirable future use, for all participants or for some. As we see in our analysis above, it seems feasible and necessary to focus more, and more widely, on the future as a vision and something that is wanted by the participating users (and researchers). This element of prototyping is important and possibly the least developed aspect of prototypes and prototyping.

**FUTURE WORK**

In this paper, we have pursued an epistemological frame of inquiry focusing on ‘how’ prototypes can act as instruments of knowledge for research. We took our starting point in Lim et al.’s work on the anatomy of prototypes [41] and Co-operative prototyping [9] to explore and develop conceptual clarity regarding people working in common around prototypes, not with a view towards design as such, as done by Lim et al., but with a focus on research. On the one hand, this has led to a much more dynamic perspective on prototyping than that of an anatomy, a perspective where the meeting and sharing among praxes and perspectives around the prototypes are central. On the other, it is also clear from the discussions of the
cases that the voice of the researchers is strong even if, in the prototyping process it can be scrutinized together with, and against the voices and praxes of the various groups of users and others. We have argued for a conceptual re-alignment to consider prototypes as objects of desire for future research on common interactive objects. The ‘deep emotional holding power’ [47] is not necessarily evenly balanced in the processes we have looked at and more work is required exploring this.

We have been inspired by the above also to consider more explicitly how and what prototypes manifest to the researchers as such, how they may explicitly work with theoretical constructs, etc., bringing together different research traditions etc., through prototyping. For this reason, we have started to conduct a series of research hackathons in our current research project [17]. These hackathons take their outset in use cases, but focus on the collaboration of researchers on how to manifest e.g their theoretical concepts and possible alternatives in prototypes, that then help explore the not-yet known. Our focus on these hackathons can be seen as an explorative interim step before taking prototypes back to users, a further issue to be explored. Through a series of research hackathons, we aim to make prototypes by exploring material practices and generate scholarly discussion explicating the socio-technical processes involved in the design and use of interactive common artifacts.

We have developed and used four seeding dynamics to analyze how prototypes act as objects of desire and explore what is ‘yet-to-be-known’ among the participants in the prototyping process. These consist of research process dynamics, use dynamics, spatio-temporal dynamics and boundary dynamics, and the analyses illustrate how prototypes help inform and unfold possible futures. These four seeding dynamics have been applied analytically to the two cases, CaseLine and LAA, in this work. More work is required to explore the generative potential of prototypes as instruments of knowledge for research involving common interactive objects. Further, our conceptualization of prototypes as objects of desire for research is intended to provoke claims about neutrality and foreground power relationships involved in developing technologies together. We contend that a desire based approach to research can help us understand and explore “norms that are internalized and enforced by appeal to ethical values, as well as to pragmatic efficacy in securing knowledge” [19]. More work is required explicating how different research paradigms, methodologies, and agendas in HCI can establish scientific rigor when considering prototypes as objects of desire.

**Conclusion**

Apart from the four seeding dynamics, we have identified five important roles that prototypes perform as objects of desire for HCI research. The paper has further explored how these roles have helped gain conceptual clarity about the role of prototypes as an instrument of knowledge for research. Despite being epistemic and not-yet-known, prototypes manifest shared visions to be scrutinized and negotiated jointly by participants in the research-prototyping process. They manifest multiple visions that may be juxtaposed, contrasted and explored, hence allowing for dynamic reiteration of visions. Prototypes become icons as material evidence and lend force to research arguments at the same time can provide disruptive justification that questions existing norms. Desires are different from needs and requirements and ought to be considered more directly in research prototyping processes.

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