Thinking About Context: Design Practices for Information Architecture with Context-Aware Systems

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Abstract
The ubiquity of low-cost, sensor-rich, mobile computing devices has meant that designing context-aware systems is now a common concern in Information Architecture. Because of how prevalent context-aware systems have become, the way in which practitioners design context-aware systems is of great importance. While design frameworks and models have been proposed for context-aware computing systems, there has not yet been research that focuses on how designers' views of context influence Information Architecture practices. To address this, we present an empirical analysis of 11 in-depth interviews with designers of a variety of context-aware systems. Our analysis of these interviews, along with a review of the artifacts produced during the design of these systems, uses the theoretical lens of professional vision to illuminate how designers view, use, and account for context in the design process. Our analysis of the artifacts and interviews reveals that designers' perspectives on context adapted as they addressed the most salient and timely constraints. This results in the designer shifting between representational and interactional views of context rather than having one fixed perspective. This finding suggests that the methods of information architects for context-aware systems need to accommodate shifting perspective on context. We present details of this activity to contribute insight into the practice of information architecture for context-aware systems.
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1 Introduction

As the sites and situations in which people interact with information systems change, so change the concerns and practices of the people who design them. Recent years have seen a dramatic shift in the nature of human-information interaction in which mobile, opportunistic interactions have begun to rival or even surpass in number and significance the stationary, focused interactions that characterized the "PC era." Moreover, an increasing number of the applications used to interact with information are "context-aware," meaning they can adapt their behavior based on aspects of the context of use, such as a user's activity, location, social relations, gestures, posture, environment, or affective state. As a result, designers of interactive information systems have begun to grapple with how context is accounted for in their work. In a sense, designers of information systems have long sought to understand the behaviors and context of the populations for whom they design to make systems that support the users' goals (Beyer & Holtzblatt, 1999; Saffer, 2006). However, the goal of such understanding was to create a system that would work well enough for most potential users in most potential situations. Context-aware systems, in contrast, seek to proactively leverage awareness of the user's context and adapt accordingly, leading to more complex applications whose behavior is generally more difficult to design, prototype, and evaluate than the relatively static systems they are replacing. To understand how the field might better support the design of this new generation of

systems, it is essential that we understand how designers are currently confronting the challenges inherent to context-aware systems.

While much has been said about the role and nature of context, there has been less emphasis on understanding how context is viewed from the perspective of practicing designers. Designers are of particular interest in the process of creating context-aware systems because of the role they play in framing how the technology is situated in the world and therefore what constitutes the system's context. Previous literature exploring the nature of context has largely been based on a pragmatic approach to what can be detected by computers (A. Dey & Abowd, 2000) or on a theoretic exploration of the nature of context (Dourish, 2004). Recent work has helped to clarify the value that taking a practitioner's perspective can provide to the larger research domain (Goodman & Wakkary, 2011; Stolterman, 2008). To take the practitioner's perspective means that we learn to understand context not as a neutral, objective phenomenon based on technology or on theoretical models, but as a construct that reflects the views of designers.

In this paper, we explore how the designer's understanding of context is represented in their tools and practices while designing information systems and how this influences Information Architecture (IA) practice. It is our contention that how designers represent context reflects their concept of context, which necessarily influences the design of an information system. By exploring the representation of context in IA, we aim to understand the role of the designer's view of context in their work. In this paper we seek to answer the following questions: first, how is context represented in artifacts for IA? What are the implications for different methods of representation? And finally, what does this suggest for IA practice as we move further into an era of context-aware information systems?

To answer these questions, we first outline the theoretical lens that we apply to understand context-aware design. We draw on Schön's theory of *design worlds* to inform our understanding of the conceptual space in which design work is conducted. Schön argues that through designers' perceptions of actual or virtual worlds, they create the objects and relationships with which they interact and determine what exists in the design world (Schön, 1992). These design worlds are abstract spaces in which designers create and evaluate these objects and relations as they work to create an optimal design. Rather than investigating the object in the designer's world, we explore how the designer creates these relationships. Our contention is that the designer's formulation and representation of these relationships necessarily influence the type of technology that is suited to exist in that design world. This means that when a designer formulates how a new design will respond to context in their design world, it is based on an understanding of context that will guide how that design relates to the real world. As Schön notes, these design worlds may be unique to the designer or shared in the design community (Schön, 1992). This suggests that explicating these worlds, and the behavior inherent to them, could help to establish a common ground to reason about modes of context-dependent interaction. To explicate these worlds, we draw on Charles Goodwin's theory of *professional vision* (Goodwin, 1994), which describes the methods used by members of a profession to shape a domain of scrutiny. For example, an anthropologist and a farmer impose different meanings on to the same substance (or "domain") – e.g., soil. Their analyses of the domain rely on different assumptions, methods of analysis, and systems of scrutiny. Goodwin argues that this process creates the knowledge that forms the theories, artifacts, and expertise that are distinctive to any professional domain. By analyzing the methods in the domain of design for context-aware systems, we can begin to illuminate the ways designers understand context as a domain of scrutiny.

To achieve a better understanding of context-aware design practice, we conducted interviews with eleven designers of context-aware systems. During the interviews, designers provided us with the artifacts produced in the design of one context-aware system they had created (Figure 1). They then walked us through the design process detailing the role of the artifacts and practices in which they engaged. This allowed us to follow the design process from initial concept to a finished product, all from the designer's perspective. This paper contributes a detailed description of the design processes of context-aware systems

from the perspective of the designer. This revealed how designers use of artifacts transforms their understanding of context from a more phenomenological perspectives to an increasingly positivist representation. It further revealed how the use of artifacts contributes to the generation of a vocabulary of codes to describe the contextual components of the system. These findings contribute unique insight to our understanding of current design practices.

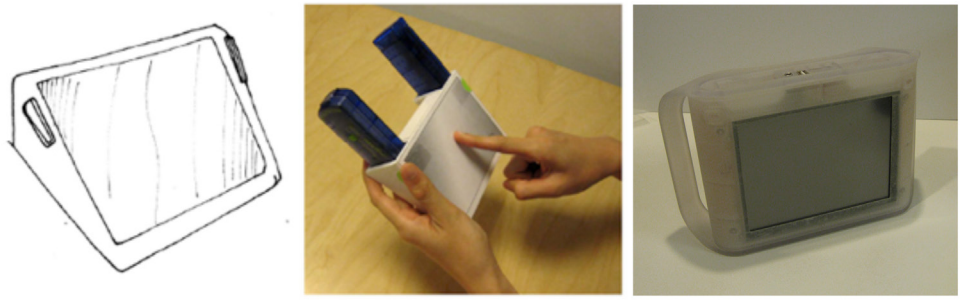

Figure 1: Artifacts from Participant 4 showing the progression of the design from an initial sketch, to a low-fidelity prototype, and then to a functional prototype.

2 Related Work

Our study is situated within a body of literature examining the role of context in IA (Morville & Rosenfeld, 2008) with special attention paid to the practices of designers. While prior work has investigated the design practice of Information Architects (Busch-Geertsema, Balbo, Murphy, & Davey, 2005) this work did not consider the role of context in the designers' work. Beyer & Holtzblatt (Beyer & Holtzblatt, 1999) have outlined the importance of understanding context of use for design. Our work differs by focusing on information systems that are aware of the their contexts of use and the implications this imposes on design. Design methods such as Experience Prototyping (Buchenau & Suri, 2000) and the closely related Speed Dating (Davidoff, Lee, Dey, & Zimmerman, 2007), allow designers to rapidly explore application concepts, their interactions, and contextual dimensions. While these methods create compelling ways to explore context in design work, they do not provide insight into how designers' are approaching the IA of context-aware systems; nor do they provide much guidance into how the understandings of user context are captured, represented, communicated, and made relevant to subsequent design activities.

Our work draws on empirical studies of designers and previous work attempting to characterize context. An important contribution to our framing comes from Paul Dourish's work investigating context and its role in design (Dourish, 2004). Dourish's work outlines the value of viewing context from a phenomenological perspective in which context arises from our interaction in the world, drawing on everyday, cultural, common-sense understandings of the nature of the social world. He contrasts this perspective with positivist accounts of context where it is viewed as a set of attributes of the world that can be objectively observed and enumerated. The positivist view of context is represented by Schilit et al. who define context as "where you are, who you are with, and what resources are nearby" and "lighting, noise level, network connectivity, communication costs, communication bandwidth, and even the social situation (Schilit, Adams, & Want, 1994)." Dey expanded the idea of context to include "any information that can be used to characterize the situation of an entity (A. K. Dey, 2001)." All three contributions are valuable perspectives, but they are formulated as academic positions on the nature of context and do not necessarily represent how context is viewed by practitioners designing context-aware systems.

The value of taking the designer's view has been an area of considerable interest. In particular, design researchers have sought to ensure that work in HCI design theory remains relevant to the larger community of design practitioners (Rogers, 2004; Stolterman, 2008). Goodman et al. note that many HCI frameworks and theories have had limited impact on professional design practice and asserts that this

disconnection reflects the inadequate attention paid to the complexity of design practice (Goodman & Wakkary, 2011). Similarly, we hope to extend the research community's understanding of context by providing a detailed account of how context is viewed by practitioners.

Previous research has supported the design and development of context-aware applications, including application toolkits (A. Dey & Abowd, 2000) and infrastructure support (Hong & Landay, 2001) to facilitate the rapid development of context-aware applications. Additionally, prior work in design tools for context-aware applications have explored the capture and playback of events for conducting user tests of context aware systems (Welbourne, Balazinska, Borriello, & Fogarty, 2010) and the playback of real world users' behavior (M. W. Newman et al., 2010). These efforts have produced a number of insights into the technical requirements for supporting context-awareness and the potential for easing the burden of development, but they have been primarily aimed at software developers who have a different set of concerns, practices, and skills than Information Architects.

To support the design of context-aware systems, researchers have taken several approaches. Prior work has sought to use *design patterns* to support the design of ubiquitous computing systems (Chung et al., 2004; Landay & Borriello, 2003). While designers did find the proposed patterns useful, the patterns were based on a review of the research literature instead of being informed by observed design practices. Dow et al. conducted a series of interviews with designers to investigate design practices for ubiquitous computing systems, which is a superset of the context-aware systems that form our focus (Dow, Saponas, Li, & Landay, 2006). This work revealed the importance of storytelling in design practices, especially when trying to communicate expectations about the context of use. However, Dow, et al.'s work largely focused on issues influencing the development of tools to support ubiquitous computing designers rather than the designers' understanding of context.

3 Study Methods

We conducted 11 video-recorded interviews with designers who had worked on recent projects that gave "special consideration to the users' context," as quoted from our recruitment email. We chose this framing to capture projects that designers described as being especially context-driven, even if the designers did not strive to meet the technical definition of "context-aware" (defined by Schilit, et al. as software that "adapts according to the location of use, the collection of nearby people, hosts, and accessible devices, as well as to changes to such things over time" (Schilit et al., 1994)). Following prior studies of design practice (Dow et al., 2006; M. Newman & Landay, 2000), we focused each interview on a single project on which the designer(s) worked in the recent past. We recruited via messages posted to several interaction design mailing lists, through personal contacts working in industry or research labs, and by directly contacting designers.

After conducting 10 interviews, we reviewed the goals of our study and decided to exclude two of the interviews from further analysis. These interviews were excluded because the process failed to meet the definition of design that we adopted from Preece et al., who characterize design as involving the "development of … a plan or scheme." (Preece, Rogers, & Sharp, 2003). The methods employed for these systems focused too heavily on implementation rather than design, and therefore were not useful for understanding design practices. Because we chose to exclude these interviews, we contacted several more designers and conducted three additional interviews until we began to see general themes emerge in the practices of the designers and therefore had achieved a point of data saturation (Bowen, 2008; Lincoln & Guba, 1985). Thus, this paper presents findings from 11 interviews (see Table 1), which included a total of 14 designers, as two of the interviews (1 and 8) were conducted with multiple designers. We took a broad view on what constituted a designer in our interviews, but all 11 interviews were conducted with individuals whose practices met Preece's definition of design (Preece et al., 2003).

ID		Years of Design Experience	System Description	Platform
1	A	1	Location-aware smartphone application for locating restaurants	Mobile phone, iOS
	B	2		
	C	0		
2		12	Wearable location and activity sensing smartphone application for logging physical exercise	Windows mobile, custom sensor suite
3		10	Small (~1 in2) display tiles capable of recognizing gestures and proximity of other tiles.	Custom-built tangible interactive device
4		3	Suite of sensors and portable educational tool for high school science students	Custom-built touch screen device with a suite of sensors
5		9	On-body activity and location sensing device and smartphone interface	Custom hardware and mobile phones
6		5	Tangible device used to promote mindfulness of power consumption	Custom tangible device
7		4	Interactive TV and ambient interface for socializing through the television	Custom hardware and commercial televisions
8	A	4.5	Location aware smartphone game.	Mobile phone, iOS
	B	6		
9		10	Location-based desktop and smartphone app for healthy lifestyle recommendations	Web applications
10		5	Location-based smartphone application for managing time	Mobile phone, iOS
11		4	Mobile application for sharing online shopping experience	Mobile phone, iOS

Table 1: Participant experience and the systems designed. Interviews 1 and 8 were conducted with multiple designers.

4 Artifact Analysis

In this section, we present an analysis of the interviews and the artifacts created by participants in the design process. To conduct our analysis, we drew on Goodwin's definitions for three practices that he argues help to frame the socially organized ways of seeing and understanding events that are distinct to a particular social group (Goodwin, 1994). Specifically, we examined the designers' work looking for instances of the following practices:

- **Highlighting:** Making specific phenomena in a complex perceptual field salient by marking them in some fashion.
- **Coding:** Transforming the materials being attended to in a specific setting into the objects of knowledge that animate the discourse of a profession
- **Creating representations:** The production and articulation of material representations

Goodwin argues that these practices characterize any professional domain, and, in fact, how they are performed establishes the basis of a profession (Goodwin, 1994). Thus, we do no argue that these three practices are unique to design, but that by examining the interviews in terms of these practices, we begin to see how designers understand context as part of their profession. In our analysis of the artifacts and

interviews, we attempted to remain neutral about what context could mean. Therefore, rather than analyzing the interviews by looking for examples of what we believed context to be based on a literature review or our personal intuition, we instead looked for representations or practices that are not accounted for in conventional computing interfaces (Hutchins & Hollan, 1985) or that relied on implicit interaction (Schmidt, 2000). Additionally, we looked for instances where the designer specifically discussed context.

To analyze the interviews, the researchers viewed the interviews and the artifacts numerous times looking for examples of highlighting, coding, and creating representations. Instances where these practices were used were then compared across the designers to look for commonalities and differences. Below, we discuss the artifacts and practices which were used to explore the information flow of the system including items such as wireframes, schematics, and sitemaps (M. Newman & Landay, 2000). We do not claim that these artifacts represent an exhaustive grouping of all artifacts that are used for understanding IA of context-aware systems. Rather, these are artifacts we encountered that were useful to designers in understanding how context and the IA of the applications intersected. Our findings are presented below, organized according to the practices of professional vision.

4.1 Highlighting Context

Highlighting is the process of making a phenomenon in a perceptual field more salient (Goodwin, 1994). In the artifacts we analyzed, we found numerous examples of context being highlighted by designers. To facilitate our discussion of how context was highlighted in design artifacts, it is useful to introduce Dobson's work on the subtleties of location (Dobson, 2005). Dobson created a taxonomy of ways that an individual's location can be determined. At the top of his taxonomic hierarchy, Dobson suggests that locations can be broken into three categories: *known, approximate,* and *negative*. For example you might now that the user is at work (*known*), that they are on their way to work (*approximate)*, or that they aren't at work (*negative*). Furthermore, Dobson's taxonomy distinguishes between knowing someone is at work (*named space*), from knowing his or her exact location at work (*absolute position*). This is only a small subset of terms provided by Dobson to describe location, but it helps us begin our discussion of the varied aspects of location that might be highlighted by designers.

The work of the designers from Interviews 1 and 9 helps to illustrate the distinct ways that location was viewed, and how this influenced what was highlighted. The designers from Interview 1 developed an iPhone application that suggested businesses to the user based on their location. The designers used text to highlight location and used a *known named space* for the location. In the wireframe we can see that the system presents results that are near the user's location "Catherines' Glen" (see Figure 2). On the side, the designers have written a note stating "Cross-street?" suggesting that cross-streets may be a more appropriate way to communicate the location to the user (see Figure 2).

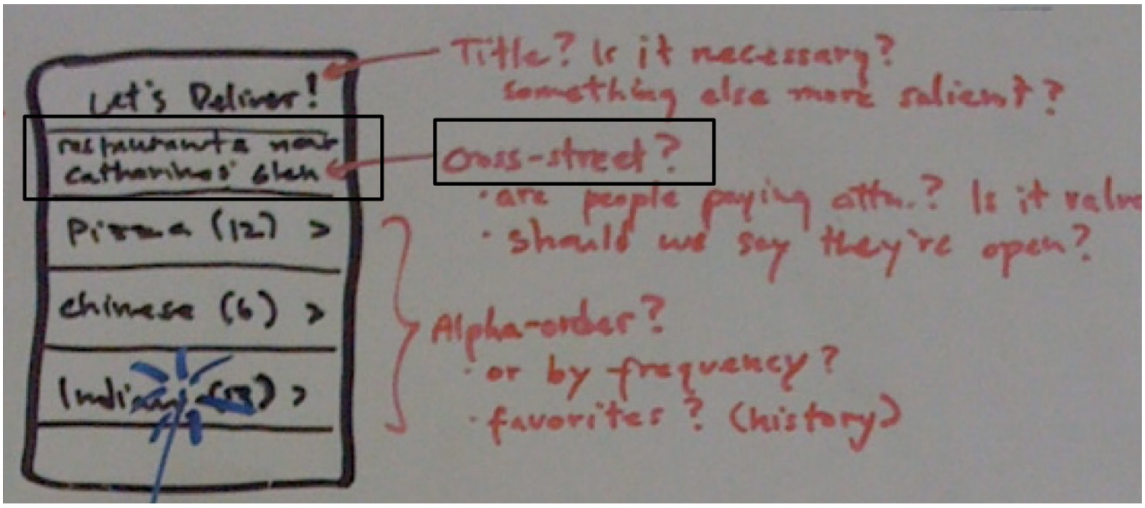

Figure 2: One frame from Interview 1 wireframes. In this frame, we can see that the designers used a known named space to describe the user's location.

In contrast to how the designers from Interview 1 highlighted location, in Interview 9, the designer depicted location as both an *approximate* and *known* location. Designer 9's work was on a system that aimed to provide healthy lifestyle options to users along their commute. Based on the user's location and destination, the system plots a route and then suggests healthy places to eat or exercise along that route. Designer 9's annotation to the wireframe states, "line plots first – dots come after" next to a diagram of a map (see Figure 3). The line highlights the location as a route—an *approximate* location—and the dots highlight specific *known* locations. By highlight both the approximate and known location the designer can use the wireframe to depict the activity of commuting as well as the system's recommendations, thereby allowing the designer to preserve multiple aspects of the user's context. The designer was clearly aware of this implication, and stated:

> **Designer 9:** "In terms of like location and context, that is a trickier one. It is one of those sort of underlying things that is part of a design that is just – to me I don't think of -- when I approach a design I don't think of location and context explicitly, it is part of – it is almost implicit. It is just one of those elements that you are going to take advantage of the design or it is the framework that you are designing within."

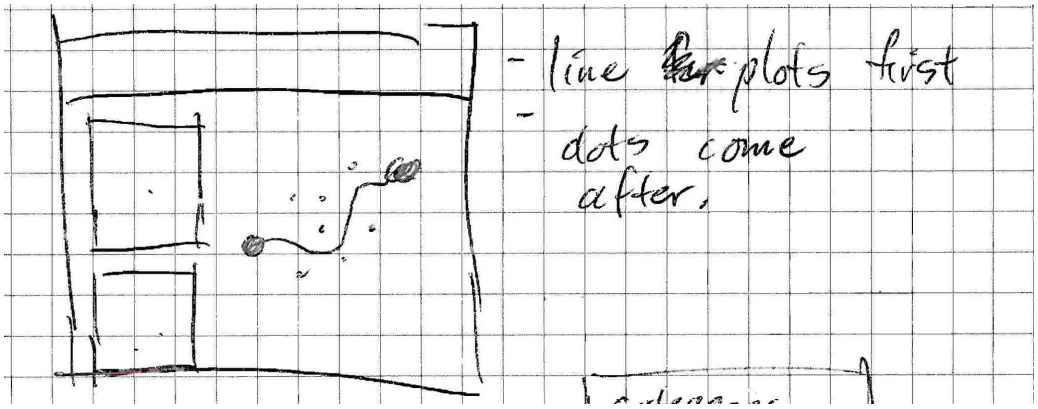

Figure 3: Wireframe-flow diagram from Designer 9 shows how the text highlights the way search results are driven by user's commute.

The quote and the features of context highlighted in the wireframe provide some insight into how this designer viewed context. We can see that the designer clearly viewed context as being multifaceted. Also, we can see that he viewed each of the components of context as being interrelated—not separate delineable components. This contrasts the view of the designer's from Interview 1 who only highlighted context in terms of the location the user occupied. This difference returns us to Dourish's work exploring positivist and phenomenological perspectives on context (Dourish, 2004). The designers from Interview 1 clearly highlighted aspects of context that could be described in positivistic terms, whereas the work of Designer 9 is better described as phenomenological. The differences between these ways of viewing context are more than purely academic; they have implications for how the system is designed as well. The implication of these different perspectives is that when—like Designer 9—context is viewed phenomenologically, it creates more ambiguity than the positivist perspective. This ambiguity allows the designer to more openly explore potential meaning for the system. However, it also creates tension between how the designer views context and how they can capture this view in their design artifacts, and ultimately their final design. In the following section, we can begin to see how designers' use of coding enables them to work with this ambiguity.

4.2 Encoding Context

According to Goodwin, coding is the process of transforming the domain being attended to into objects of knowledge (Goodwin, 1994). We found that coding often drew on the phenomenon designers highlighted in their work. What distinguishes coding from highlighting is that highlighting draws attention to features of context. Codes define the highlighted features or the behavior of the system in response to those features. Our observations of how coding figured into the designers' practices revealed two prominent themes. First, coding allowed for the instantiation of a vocabulary about context. This instantiation occurred when the novel aspects of these systems required designers to develop new vocabulary to communicate ambiguous aspects of the context. Secondly, these codes were then used as a method to communicate design constraints or technological requirements throughout the design process.

We found a particularly illuminating example in our interview with Designer 2. During the interview, she discussed her work developing a smartphone application that would detect and respond to the user's exercise activities, such as running, walking, or riding a bike. She used four different colors of sticky notes to represent the screens of the application. The sticky notes of a certain color were used to reflect screens that would pertain to the type of context detected (Figure 4). The designer used orange for location, blue for time, purple for activity, and pink for "system triggered," meaning that no signal was detected and therefore the system was possibly not being used. Each sticky note represented a UI screen or a concept that a screen would need to be designed to accommodate. The designer's color-coding of the context highlights how the screens are organized, and also helps to establish a *coding schema* (Goodwin, 1994) for the various components of context dealt with. The codes may seem unremarkable—location, time, activity, and no signal—but they were an important enough way to organize the wide range of activities of the system that the designer felt it necessary to meticulously organize the information according to this coding system. In addition, laying out the information this way enabled the designer to consider if it would be capable of detecting the components of context in question. She stated:

> **Designer 2:** "And see here, you can see in this one there's a question that we wrote and there's a big [collaborating developer's name] with a question mark so we would bring him over and there's another [collaborating developer's name] with a question mark. So [collaborator] was working with [different collaborator] and so when we would hit some 'Ooh is that even possible?'"

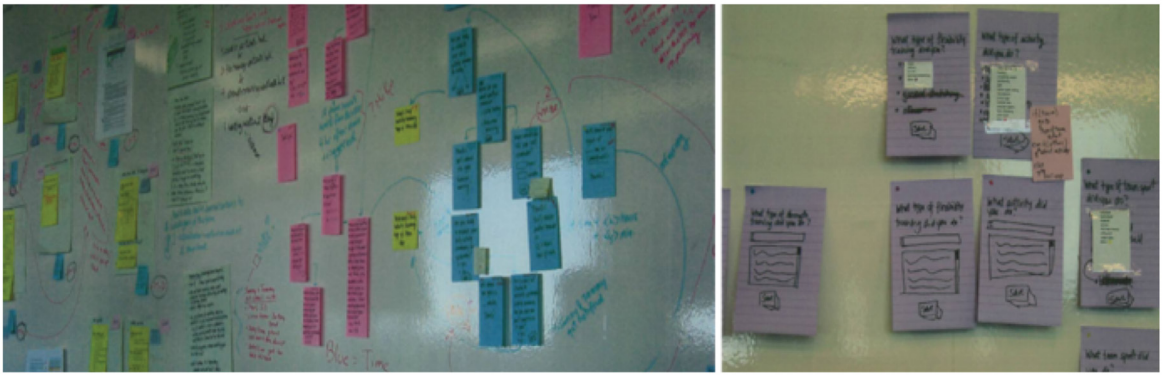

Figure 4: Designer 2's sitemap shows how the color of the sticky notes encodes the relevant forms of context to which the screens correspond.

This quote illustrates two interesting points. First, the designer used this framing of context to consider the feasibility of the system, which is a necessary in the production of any technology. Second, it shows that encoding context in this way allowed her to engage with other collaborators to resolve the issues of feasibility. This suggests that the codes became the vocabulary with which the feasibility of context-awareness was discussed. Of additional interest is the fact that this artifact persisted in a public space in the participant's lab for weeks, which enabled her to discuss the system at length, thereby helping to solidify and propagate the coding schema.

> **Designer 2:** "So we would bring people to the board constantly and people were fascinated with us at the board. I think just having these artifacts and colored things and us just sitting there staring brought a lot of people over and they would ask about it, follow the progress."

The fact that this artifact operated as a conversational locus suggests that coding is a social process. This helps to establish that the codes were useful, not only in reasoning about the system, but also in creating a common language to discuss the system. When the designer initially used color-coding to define the functional sections of the sitemap, she did not consciously encode a given way to discuss the system. However, through color-coding, she facilitated discussions of the system by creating an easy way to see how the context of the system would influence the architecture. This allowed her to discuss the implementation with the engineers working out how context was detected by the system. The example of Designer 2's color-coded sitemap begins to suggest how codes can help to span design worlds.

Designer 2's work demonstrates how current IA artifacts are augmented by coding schemas to communicate how context influences the state of an information system. Designer 2's use of color-coding added an additional dimension to the 2D space that the sitemap occupies. By providing an additional dimension to the sitemap, coding acts as a useful mechanism to communicate how context influences the system. While Designer 2's work provides a vivid example of the use of coding, she was far from unique in using codes to express the context of the system (though she was the only designer to use color to this end); in each interview, we found that the designers added additional dimension to sitemaps and wireframes through the use of coding. This was most commonly done through the use of text annotation on wireframes and sitemaps, but we also saw designers use illustrations, color-coding, and moving the location of notes to communicate changes in the user's location. To summarize the different ways that coding was used in the interviews, below is a table of the information artifacts from the interviews and the modes of coding they contained (see Table 2). These examples of coding begin to suggest the importance of how context is represented in design practice. In the following section, we continue to explore how designers viewed context by detailing the role of representation.

ID	Wireframe	Sitemap	Combined wireframe/sitemap
1	*	*	Text, illustrations
2	None	Color-coding	Text, color-coding
3	*	*	Text, illustrations
4	Illustrations	Text	*
5	None	*	Text, illustrations
6	*	Text	-
7	*	*	Text
8	Text	*	Text, illustration
9	Text, illustrations	Text, location	*
10	Text, illustrations	None	*
11	*	*	Text

Table 2: Summary table of the artifacts used by designers and which methods they used to encode context in the artifacts. In instances where designers used multiple wireframes or sitemaps, the methods of encoding used in the artifacts are combined.

4.3 Representing Context

The contrast between the designers' work has helped to illuminate the diverse perspectives on the nature of context. The contrast illustrates how the designers adapt artifacts to reflect varying perspectives and approaches to understanding context. While all artifacts are representations of elements of the design space, we found that designers endeavored to include representations of context in their work. To accomplish this, the designers created multiple representations of context and the system, which allowed them to overlay components of context on the system. One example of this practice came from Interview 8. The designers drew a simple grid representing a map on a glass table and a mockup of interface on a dry erase board. The designers would make changes to the location by pointing to the squares in the grid drawn on the table. They would then see if the changes in location could be accommodated by a wireframe of the interface (Figure 5). This created a way to represent the location and the system in tandem. By juxtaposing these representations, the designers were able to see how the user's implicit interaction in the world and their explicit interaction with the system would influence the state of the system.

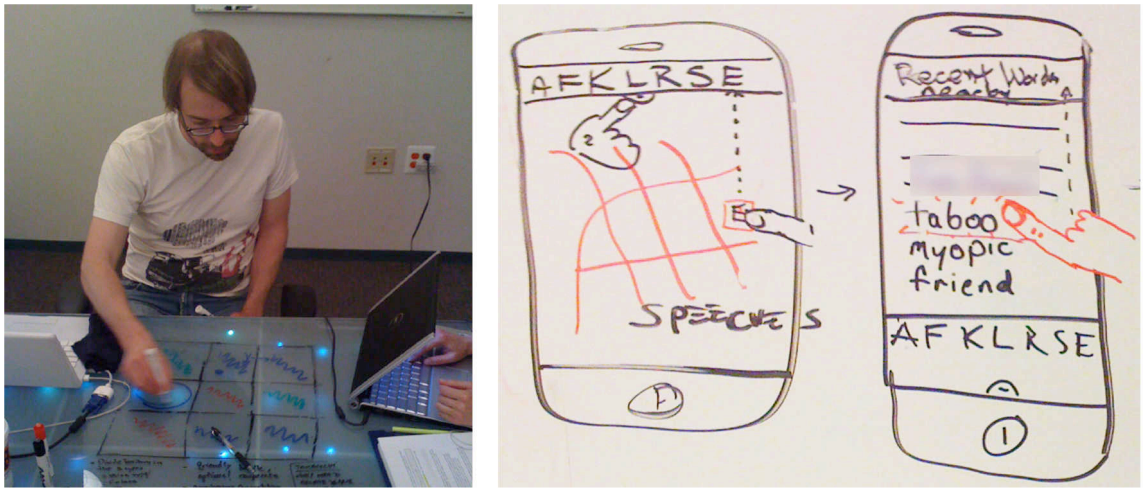

Figure 5: A grid drawn on a glass table and a wireframe drawn on a white board. The drawings on the table were used in conjunction with the wireframe to show how changes in location (drawn on the glass table) would affect and be represented in the interface.

This method of representing context was unique to the designers of Interview 8. However, we did see additional methods to address how context influenced the system. The other methods we encountered in the interviews involved more complicated techniques, such as experience prototyping (Buchenau & Suri, 2000) or developing functional prototypes. This suggests that methods to represent context and its influence on a system are still being developed, but are indeed needed. An interesting aspect of this technique is that by representing the context the designers necessarily reduce what could account for context to a single dimension, namely location. Thus, it seems that while this method was helpful, it does narrow the designers' perspective on what constitutes "context."

5 Discussion

Based on our analysis of the interviews, we found that when working with context-aware systems, designers adapt "standard" information structure artifacts to highlight, encode, and represent context. Highlighting features of context within familiar artifacts causes designers to distill the complicated notion of context down to the pertinent factors needed to express the concept in a manner the artifact affords. This process leads designers to create a vocabulary of codes to express the behavior of the system. By adapting existing artifacts, designers can consider the constraints and opportunities of context alongside other long-standing concerns such as information presentation. This was clearly seen with Designer 2's color-coding of context. Designer 2's color-coding provided an additional dimension to help her reflect on the role of context, but additional dimensions cannot be added indefinitely. In light of this, we believe designers should be careful to acknowledge the features of context their artifacts represent, as well as omit. Through careful reflection on how context is highlighted, encoded, and represented Information Architects will be better suited to address the unforeseen consequences that arise from context-aware systems.

The contrast between which artifacts were chosen and how they were applied sheds light on the tension between phenomenological and positivist views of context. Designer 9's use of *known* and approximate locations while highlight context demonstrates that both perspectives exist in contemporary design practice. Interestingly, we see that both perspectives are present within individual projects and are being applied by individual designers. While we are reluctant to make claims about consistent temporal patterns for activities and artifacts based on our study, our data suggests a provisional alignment of the phenomenological perspective with earlier design stages and of the positivist perspective with later design stages. This makes sense because as the system progresses, it becomes increasingly necessary that designers communicate the design constraints in ways that can be captured and processed by computer hardware and software. This finding suggests that design tools for context-aware computing may need to accommodate shifting perspective on context.

One limitation of our study is that we relied on artifacts and the designers' recollections of practices. As we discussed above, it is our view that the process of creating artifacts necessarily influences the way context is represented. Relying on the artifacts may have influenced designers to think about the process in terms of the representations of the process, which may create a bias toward a positivist interpretation of context. Practices such as experience prototyping (Buchenau & Suri, 2000) serve to represent the designer's concept of context, but relying on their memory of the practice undoubtedly loses some of the richness that being there would reveal. Despite this limitation, we do feel that the designers were able to discuss their design practices with sufficient detail for our analysis. However, an ethnographic study of context-aware design practice would be a valuable way to explore this topic in future work.

Our analysis revealed the importance of generating and communicating codes to the members of the design team and the role that various artifacts play in the design of context-aware systems. This finding draws our attention back to Schön's discussion of design worlds. Schön argued that design worlds may be unique to a designer or shared across a broader community (Schön, 1992). This suggests that an analysis of the specific codes could help to establish a common vocabulary for context-aware design. Along similar

lines, Garrett has attempted to establish coding practices for general IA practice using a "visual vocabulary" (Garrett, 2002). Initiatives to facilitate designers' communication around their context-aware design practices could serve to facilitate the emergence of standard codes or coding practices. As the field of IA moves forward, it is our belief that these coding practices will become essential to establishing widely adopted design patterns.

6 Conclusion

In this paper, we have sought to contribute to the understanding of context-aware design by analyzing the artifacts and practices of designers. Our findings suggest that designers employ differing views on the nature of context. Their views on context also change as they engage in the design of a system. This change seems to be generally from a more phenomenological perspective to a more positivist perspective and results from the process of highlighting and representing context that encode the relevant features. The produced codes are then used to communicate with other stakeholders in the design process and ultimately evaluate the design. The process is not a straightforward march, but relies on creating multiple representations of the context that are evaluated for different forms of context and by different stakeholders. Designers moved back and forth between understandings of context as they sought to satisfy design constraints.

We conducted our analysis by relying on the theoretical lens of professional vision. This lens gave us insight into the way that designers viewed the domain of context-aware design. As the field of IA continues to mature, it will be informative to see how the practices and perspectives we outline in this paper transform. We present this work in hope that it will contribute to the grounding of future IA practice in empirically grounded work. We believe that through our analysis, we have demonstrated the value that using professional vision as a theoretical lens can contribute in exploring design practice. Furthermore we hope this work has helped to outline the value of attending to the role of the designer in the production of information systems.

7 References

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