From Human Factors to Human Actors to Human Crafters:
A Meta-Design Inspired Participatory Framework for Designing in Use

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For Annabelle, who sat patiently by my side during countless hours of writing. And for my father, John Maceli, who inspired me to pursue a career in academia and who made it my home.
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Abstract

From Human Factors to Human Actors to Human Crafters: A Meta-Design Inspired Participatory Framework for Designing in Use
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Meta-design theory emphasizes that system designers can never anticipate all future uses of their system at design time, when systems are being developed. Rather, end users shape their environments in response to emerging needs at use time. Meta-design theory suggests that systems should therefore be designed to adapt to future conditions in the hands of end users. Meta-designers must provide the flexibility for end users to create and shape their own tools through a process of continuous co-design. Knowing that future use can never be entirely anticipated, this dissertation explored meta-design inspired techniques to help anticipate some use time possibilities at design time.

This dissertation describes a series of experiments exploring the use of meta-design inspired guidelines as design heuristics in a continuous, participatory co-design process. The experiments consisted of a laboratory study exploring the effects of the meta-design inspired guidelines and end-user participation on design time ideation, a design exercise employing the guidelines on a redesign of the ipl2 digital library (http://www.ipl2.org), and a diary-keeping exercise with ipl2 end users. These series of experiments contribute needed empirical work to further our understanding of meta-design and related key concepts, such as end user motivation. The empirical work indicated that the meta-design inspired guidelines were useful in sparking future
focused design discussion in groups of designers working at design time, as well as to
shift the types of design ideas generated towards building features supporting end-
user customization and modification in use. This research contributes an
understanding of the desirable properties of a successful meta-design system, in
relation to the customization features and functions, as well as the motivations of end-
user crafters.

Meta-designers must anticipate future end user needs enough to provide the
necessary tools for end users to customize the system at use time. This dissertation
demonstrates that methods at design time can help to shift design thinking towards
such future modifications in the hands of end users. This begins to bridge theory and
practice in the research area of meta-design, by exploring new design methods to
bring meta-design concerns, such as future customizability, to the forefront of design
time work.
1. INTRODUCTION

In recent years, the availability and ubiquity of technological artifacts has exploded as hardware developments simultaneously drive down price and increase power. New means of user-empowered information production, vastly different from traditional software development practices, have emerged. As designers, we are increasingly faced with complex, unanticipated, and changing scenarios of use, spanning multiple devices and contexts. These rich, changing contexts are poorly supported by our current design methodologies which are very far away, in time and in space, from these future contexts of use. As Moore’s law dictates, computing power increases constantly; in a world of ubiquitous computing this means more devices, more power, and more ubiquity yet this movement only increases the gap between design time and use time, making our job as designers increasingly difficult.

An attempt to broach this distance necessitates further shifting the process of design towards, and ultimately into, the setting of use.

At one time, design and use were closely entwined activities: human crafters designed tools through use and there was no distinctly separate design process. As technology advanced, industrialization introduced a divide between the goals of the setting of design (design time) and the setting of use (use time) (Figure 1 below). Design time focused on experts creating a completed design artifact, while use time was oriented towards gradual user-driven evolution and change, responsive to environment and context. This tension between what could be accomplished at design time and what unpredictable situations the system would encounter during use has
been an ongoing challenge to the evolving field of Human-Computer Interaction (HCI).

![Diagram](image)

**Figure 1: Human crafters phase (design time and use time closely entwined) to human factors phase (divide emerges between design time and use time)**

When environments of use were constrained to the workplace, early HCI methodologies could strive to match known work tasks with suitable interfaces; this *human factors* approach focused on the line between man and machine and the interfaces that afford interactions between the two. In the 1990s, when technology moved into the home and into more complex environments of use and practice, HCI methodologies began to take a broader view of interaction, supporting *human actors* who controlled the technologies used in their daily lives (e.g. Bannon, 1991). Current HCI methodologies and theories are largely oriented towards this “human actors” relationship between technology, users, and use. Recently developed technologies have allowed for complex and shifting contexts of use (Bødker, 2006) as well as empowered users to design their own technological environments. Novel means of
information and technology production (e.g. open source software development, mash-ups, commons-based peer production (Benkler, 2006)) have radically changed the technological landscape. Users are again behaving as human crafters – controlling, designing, and developing not only their relationships with technology, but the very form and function of this technology.

As a result, traditional HCI design time activities have become increasingly ill-suited to the unpredictability of real life use. As users become more empowered to design their own technology environments, HCI theory and methodology must shift as well to better support and shape these activities. In order to address these challenges, the conceptual framework of meta-design (Fischer & Giaccardi, 2006) suggests redirecting our attention towards bridging the differences between design time and use time through systems and techniques allowing the system to evolve in the hands of its end users over time. Users function as both consumers and designers of their environment and the boundaries of system design are extended from one original system to an ongoing co-design process between users and designers. Within such a model, meta-designers are tasked with both creating the socio-technical environments for others to conduct their design activities and creating the conditions, both social and technical, to encourage diverse participation in design (Fischer, 2003). Such behaviors have already emerged in our current technologies, which support end users modifying systems in a variety of ways, from adding content (e.g. blogs, wikis) to functionally modifying and extending systems (e.g. Google SketchUp).
1.1 Motivation and Research Approach

As a meta-design approach reinforces, future use can never be entirely anticipated, yet some work must happen at design time. It remains a challenge in information systems to orient design time conversations towards future use time and to understand the role of participation in such a process. This raises the key questions: what techniques can help anticipate some use time possibilities at design time? And how can designers and users communicate around the inevitable and unanticipatable future changes that will arise over the life of the system?

These highly complex environments of use, consisting of rapidly evolving technologies and new means of information production, require a new focus for design activities. Design power is shifting towards the end user; as designers and as researchers we must learn how to think about designing for such a world. That is, we must begin to predict the future context in which the users will work. In this research study, a series of guidelines aimed at orienting design time activities towards future use, as well as providing a frame for users and designers to communicate changes across the entire life of the system are explored. These guidelines are based primarily on literature and recent technological trends and were validated with real world designers and users.

As mentioned early, a primary goal of meta-design is to facilitate end-user modification at use time. To this end, the *meta-design inspired guidelines* are a technique that seeks to focus designers on possible future motivations of end-users and the necessary environmental tools that must be provided to empower end-users to
shape their system in use. In this sense, the guidelines are meta-design inspired, and seek to contribute another practical technique to meta-design. A laboratory study was first conducted to assess the usefulness and understandability of the guidelines to both designers and end users. In order to better understand their potential application to real world design activities, a subsequent ipl2 design exercise was undertaken in which the guidelines were used with an existing website’s design team working with end users.

The intention of the guidelines is not only to focus designers on future contexts of use, but to provide a framework to facilitate participatory co-design – between end users and designer – in a continuous fashion – over the life of the system. In this continuously participatory co-design, users and designers contribute to an ongoing design discussion centered on modifying the system in use. A process of continuous participatory co-design, in which users and designers contribute to an ongoing design discussion centered on modifying the system in use, is an achievable goal in the present, moving us closer to a future of true meta-design.

This dissertation begins to address the challenge of continuous, participatory co-design and explore how such principles can help anticipate future changes in the hands of end users. This is a complex problem with no easy solution. This study begins to fill in the gap between design time and use time, moving design time towards use time and towards end users designing-in-use.
1.2 Reading Guide

Chapter 2 explores the ideas of meta-design and continuous, participatory co-design in historical perspective; looking at the evolving relationship between design time and use time and how that motivated the developing field of human-computer interaction. Following the historical overview, current work in meta-design is assessed, from both within and outside of the field of information systems, and gaps in practice are identified. Finally, the goal of continuous, participatory co-design is assessed against future directions for the field of HCI and the rationale behind the meta-design inspired guidelines is described.

Chapter 3 builds on the gaps in practice identified in Chapter 2 by expanding the guiding research question into a series of four research questions to further our understanding of continuous, participatory co-design. The rationale for each of the questions is detailed and mapped to two experiments, one in the laboratory and one with the design team of a digital library (ipl2; http://www.ipl2.org), assessing the usefulness of the meta-design inspired guidelines.

Chapter 4 describes the experimental research design in relation to the series of four research questions. The rationale for each of the meta-design inspired guidelines is described in greater detail, in relation to both literature and current design practices and trends. The data collection instruments are provided, in addition to the independent and dependent variables that were collected and analyzed. Justification for the inclusion and collection of these variables is provided.
Chapter 5 provides the results from the laboratory study and the ipl2 design exercise, as described in Chapter 4. The findings are structured by experiment and research question.

Chapter 6 discusses the findings in greater depth, exploring the effectiveness of the meta-design inspired guidelines and end-user participation on focusing users and designers on future contexts of use. The overall contributions of this research work are discussed, around concepts such as end-user motivation, quality in meta-design systems, end-user customization, and the application of such findings to real-world contexts.

Chapter 7 concludes the dissertation with a summary of the research approach and the main contributions of this research, as well as potential directions for future work and the implications for both practice and research.
2. LITERATURE REVIEW

The following review of literature aims to put the idea of continuous participatory co-design in historical perspective as well as explore relevant theory and methodology oriented towards this concept. Continuous participatory co-design refers to design activities that are: continuous – extended across time and place, and participatory – contributed to by both designers and end users. This collaborative process of co-design is one that has its origins in the earliest acts of design and continues to evolve in the present with our current technologies and design processes.

The following literature review will explore continuous participatory co-design in greater depth, addressing the changes in the gap between design time and use time over time, and the relationship between these changes and the HCI theory and methodology of the period. Beginning with early design theorists and practitioners, whose visions still have implications for present-day design, the literature review will begin by describing how design was conducted by early human problem-solvers. In this time period, design time and use time were closely entwined with early designers often playing both roles, as human crafters of their tools. The subsequent industrialization period introduced a shift in this relationship; the gap between design and use began to widen and the “official” roles of designer and user emerged in a focus on human factors. In more recent times, when computing devices moved into the home and into our daily lives, end users became active consumers of their technologies and design methodologies supporting human actors as participants in design arose.
Moving towards the present, our most recent technologies have begun to enable end-users to contribute to and modify their systems in use; new models of information production and sharing have emerged, in which end users are motivated to conduct design activities in their technologies. End users have begun to act as *human crafters* once again, as designers we must approach design as continuous participatory co-design supporting this process. In addition to a historical perspective, the literature review will explore recent participatory approaches in both theory and methodology with relevance to the problem of supporting end-user crafters. This lends necessary historical context within which to frame and assess the existing approaches to the challenge of designing in use. Finally, this review of literature will address a few forward-thinking visions of the future, made by key technologists, that have relevance to the concept of continuous co-design. The sections of the chapter are structured as follows:

2.1 In the Beginning: Human Crafters

2.2 Fitting Man to Machine: Human Factors

2.2.1 The Emerging Field of Human Factors

2.2.2 The “End User” Comes Into Focus

2.3 Users as Active Agents: Human Actors

2.3.1 Situated, Emergent Environments of Use

2.3.2 The Unsolved Problem of Designing in Use
2.3.3 Practical Processes of Design

2.4 A Return to Designing in Use: Human Crafters

2.5 Designing for Design in Use

2.5.1 Understanding the Complexities of Use Time

2.5.2 Is Participatory Co-Design Possible?

2.6 Meta-Design: Conceptual Framework

2.7 What’s next for HCI?

2.1 In the Beginning: Human Crafters

People have practiced design for roughly 2.5 million years. Many definitions and understandings of the concept of design exist. Herbert Simon articulated a broad and inclusive notion of design and designers, claiming that “Everyone designs who devises courses of action aimed at changing existing situations into preferred ones” (Simon, 1996). As Mayall describes in Principles of Design (1979), design, viewed as the creation of artifacts used to achieve some goal, traces back to the development of stone tools. No formal descriptions of design methods or design theories have survived from these early design efforts, and it is doubtful that they existed. Mayall (1979) notes that early design was driven by the belief that new is better and that technology is good. The earliest designers did not worry about unintended effects that their artifacts might have on individuals or society, and they did not spend a great deal of time focusing on user needs. New is better and technology is good, and stone
tools were clearly better than what preceded them. That groups of people might work together, that the context of use might influence design, that people might have need for multiple tools at one time or might use one tool in multiple ways or unanticipated ways were not factors that needed serious consideration.

Design in this phase was a common human activity, describing a general process of identifying environmental misfit and moving towards a more desirable state in pursuit of some goal (Alexander, 1979). Design time and use time were once intermixed; nearly anyone could do it or be witness to it, tools were designed through use, there was no separate design process, and there were certainly no experts conducting the “science of design”. For many, many years, this is how design was conducted, either individually or in closely knit groups such that there was no divide between designers and consumers and (to some extent) between design time and use time.

Technology, in the form of increasingly specialized tools, was developed and continuously improved either in or close to the environment of use; there was little focus on or need to modify this process of design. The artifact’s misfit (Alexander, 1979), or inability to perform its function (on any number of dimensions), was the motivating factor for design changes. As Petroski claims, form does not follow function, but rather “what form does follow is the real and perceived failure of things as they are used to do what they are supposed to do” (1992, p. 20). Design can therefore be described as a series of small, successive changes, one following the next and “all intended to be for the better” (Petroski, 1992, p. 28). This small-scale, often
trial-and-error, iterative movement away from misfit towards a better solution characterizes the vast majority of historical acts of design, and many acts of design today.

This iterative approach to tool design not only increased our technological capabilities and structured our environments, but also set the stage for early humans to plan, communicate, and cooperate. This ultimately led to a movement away from hunting-and-gathering and towards structured, permanent civilizations (Burke & Ornstein, 1997). In this environment, as the complexity of our technological tools increased, specialization in the skills and knowledge to create tools became highly valued. This specialization increased the knowledge and skills necessary to pass from generation to generation and began to stratify societies into those with and without such technological developments (Norman, 1993). A higher and higher level of schooling was necessary to achieve mastery of such skills. Even so, moving into the industrial revolution, many of the enabling technologies arose from the work of practical inventors and entrepreneurs, often with little education and theoretical knowledge in the sciences (Stokes, 1997).

At the time of the industrial revolution, there was a noticeable shift in who maintained the skills to conduct design in an increasingly technological world and to what end; the following section will assess these developments and their later implications on the field of human-computer interaction. In respect to this early phase of human crafters as described briefly above, several notable themes have implications for the study of meta-design. First, these early design efforts were
inherently *continuous* – artifacts were iteratively improved throughout the life of the object. Secondly, these design efforts were *participatory* – artifacts were developed close to the setting of use by the user or someone close to them. Next we will explore the beginnings of the industrial revolution and how these approaches changed.

### 2.2 Fitting Man to Machine: Human Factors

With the industrial revolution came a huge increase in machine based manufacturing, and work practices in turn began to focus on efficient separation of labor. It is around this time that the focus of design shifted from the tools themselves, to the creation process. During this time period, machinery was operated by humans in the context of work and rarely, if at all, by choice. Attempts to improve this “non-discretionary use” (Grudin, 2005) focused on increasing the speed, safety and efficiency of known and constrained work tasks. Industrialization introduced and reinforced a divide between the producer and consumer, and “high tech scribes” (those fortunate enough to have system building skills) begin to monopolize both the design and the solution of tools and systems (Fischer, 2005). It is during this time that the divide between *design time*, where systems are constructed by experts, and *use time*, when the systems are used by end users, begins to broaden.

During this manufacturing-focused time period, there was no need to customize machinery to its users, beyond simply improving efficiency of known tasks. Furthermore, designers of such machinery had a clear idea of how these systems would be used and the environment of use. In this machine-centric phase, Dreyfuss was one of the first, if not the first, product designer to focus on that fact that the goal
of design was to fashion artifacts that people could use. Very early in the formalization of design methods, he noted that “We bear in mind that the object being worked on is going to be ridden in, sat upon, looked at, talked into, activated, operated, or in some other way used by people individually or en masse” (Dreyfuss, 1955). Although a focus on people may sound commonplace today, it was revolutionary in the 1950s.

Prior to World War I, engineers had begun to study issues such as workplace performance, the effects of training, and design for the handicapped, using now commonplace techniques such as data gathering and statistical analysis (Meister, 1999). Frederick Taylor, in *The Principles of Scientific Management* (1911) and other writings, described means of improving worker performance through detailed step-by-step analysis of work practices based on time and motion studies; thereby reducing steps, yielding reduction in time and increased productivity. This “scientific” approach to work practices attempted to uncover the “one best way” for the task to be conducted, which could then be employed by management (or the designer of the process). The focus during this period was largely on fitting man to machine (e.g. tank operators were the soldiers small enough to fit inside) or man to process and not the reverse and there was an insufficient body of work to crystallize these efforts into a formal field of study.

The explosion in technology around the first and second World Wars yielded many complex new wartime systems. Design flaws in these systems resulted in the inability for human operators to adequately operate these systems, often with fatal
results (Grudin, 2005). These misfits resulted in a renewed interest in human capabilities and how physical equipment might make best use of these skills (and, conversely, avoid known human cognitive or physical limitations).

Around this time, a few visionaries began to describe a future in which computing devices might enhance our daily lives, greatly increasing our problem solving and creative capacities. Wild ideas at the time, many of these concepts are now common elements of technology we use on a daily basis. Perhaps most influential, Vannevar Bush’s 1945 essay “As we may think”, identified issues of information storage and retrieval as key to making human knowledge accessible and useful. Bush also conceived of a hypothetical system, the Memex, within which he predicted many technologies in common use today, such as hypertext, the Internet, personal computing and speech recognition (Bush, 1945a).

Beyond these technological predictions, Bush’s other writings during this time period spoke to the role of and relationship between science and technology in the postwar era (Bush, 1945b). In ideas that helped shaped the postwar paradigm for scientific research for years to come, Bush described an ideal separation of “pure” and “applied” science, in which pure or basic science must be shielded from thoughts of practical ends in order to best further understanding of the phenomenon of study. In a linear process, applied research then performs the role of transforming these scientific gains into technological innovations (Stokes, 1997). A governmental policy towards scientific research evolved in which universities and research centers were supported in conducting basic science research, often divorced from real-life use and
application. This would later set the stage for early research in HCI as confined to the laboratory and pursuing scientific ends, such as cognitive modeling of human processing and behavior, separated from real world use of systems.

2.2.1 The Emerging Field of Human Factors

In this technologically turbulent postwar era, Meister notes in his history of human factors that, a “critical mass of technology and personnel” (1999, p. 149) had finally been reached and the field of human factors coalesced, with the creation of the Human Factors Society in 1957, and the subsequent production of the Human Factors journal. The 1950s also saw the publication of several influential handbooks in human factors (e.g. Fitts, 1951; McCormick, 1957; Woodson, 1954); successive generations of engineering psychology students would study these guides covering best practices for equipment design. Computer technology continued to overcome key limiting factors, such as the use of failure-prone vacuum tubes, and evolved towards solid-state implementation; the commercial release of such machines in 1958 led to increased availability and importance of the role of computer operator, who were responsible for direct manipulation of the computer system (Grudin, 2005). Experts in the growing field of human factors took up many of these interface concerns and published some of the first articles in the field of human-computer interaction (e.g. Shackel, 1959; Smith, 1963).

This early research (and many handbook guidelines) focused on computer systems tailored to fit human operators in the context of required work. The tasks addressed were bounded by the work, with little consideration to factors outside this
scope, and these tasks were similarly well-defined: by the roles and responsibilities of the job. The use that human factors engineers addressed at this time was therefore both constrained and highly defined. These handbooks brought a formal focus towards the process of design and towards considering users as the ultimate consumer of the system, albeit a narrow work-centric view of the user as an element of the system whose limitations must be designed around.

The domain of personal computing was also developing in the 1950s and 1960s as scientists were beginning to consider how humans and computers might interact directly to facilitate problem solving and other creative activities (Baecker & Buxton, 1990). Grudin details how the predictive ideas of this period “described a world that did not exist, in which people who were not computer professionals were hands-on users of computers out of choice” (2005, p. 4). These ideas offer glimpses into a world in which computing might serve goals beyond the workplace, and move into our homes, and leisure time.

Though the work of such visionaries as Vannevar Bush was far from being fully realized, other futurists continued to explore the role that computing might play in our lives. Licklider’s (1960) influential article described “man-computer symbiosis”, in which he developed ideas key to the eventual development of artificial intelligence. In his view, machines need not simply extend human capacities, by completing human-dictated tasks and data processing with known outcomes. Rather, machines could assist humans in working through complex, real time, trial-and-error problems revealing “flaws in the reasoning or unexpected turns in the solution”.

Machines, then, might perform in a symbiotic relationship with humans, helping to design solutions through use.

Several key technological systems and means of interaction, now commonplace today, came into development during this time period in research laboratories, including text editing, graphical interfaces, and the mouse. Highly influential projects include Sutherland’s Sketchpad in 1963 (Sutherland, 1963) which explored a novel way of interacting with computers, through a graphical user interface. At the time, computers were given commands by operators through punch cards, and the graphical user interface was a huge step forward in reducing end-user complexity and making the personal computer a reality for everyday consumers. In the late 1960s at Stanford Research Institute, Doug Engelbart developed the On-Line System (NLS) exploring and developing graphical interfaces, hypertext and the mouse, which he later patented in 1970 (Myers, 1998). Perhaps most interesting, Engelbart’s work focused on collaborative activity and communication, in what would ultimately be the beginnings of computer-supported collaborative work and a primary driver for personal computer use, networking, and the Internet (Engelbart, 1962). In 1968, the first user interface management system (UIMS) was conceived by William Newman, which began to put flexible toolkits for software interface building into the hands of developers in his Reaction Handler system (Newman, 1968). UIMS would become key to the development of future computing systems, enforcing interface standards and allowing for modular system building, with a separation of display and business logic.
2.2.2 The “End User” Comes Into Focus

By the 1960s, new technologies and new uses for systems had reached the point where it was becoming clear that something needed to change about the way we thought about design. Christopher Alexander (1964) acknowledges in *Notes on the Synthesis of Form*, that many design problems were reaching “insoluble levels of complexity.” Design problems that once looked simple and that had simple solutions now looked more complex and new, more formal approaches to design were proposed.

These advances confronted technological challenges and theorized future capabilities; there was still little thought to end users, as we consider them today. Technological developments were making strides towards personal computing for non-programmers, but a cohesive vision of what that might look like technologically did not begin to emerge until the 1970s. During this period, human factors engineers continued to build a body of publications, and a strong technical group oriented around computer systems research emerged. The *International Journal of Man-Machine Studies*, focusing on computing, began publication in 1969. The popularity of programming had greatly increased and, along with the general computer systems, became the topic of various research efforts (e.g. Weinberg, 1971) and many articles. As with earlier efforts, “most viewed programming in isolation, independent of organizational context” (Grudin, 2005, p. 5). Organizational context (as well as many other dimensions and definitions of context) would not be a strong focus of research until twenty years later, although Lucy Suchman would pioneer contextual field work
methods in her early studies of copy machine use in 1981 (Suchman, 1987). These human factors studies of programmers mark a conceptual shift towards the “end user”; in this research, the end user becomes someone tasked with more complexity of purpose than a simple work operator, and the work often becomes discretionary.

Technological gains had paved the way for the shifting nature of the end user, and this unidirectional relationship would continue for some time. The personal computer was a mere decade away from becoming a reality, followed by years of explosive technology growth that would create many challenges for the developing field of HCI. The Xerox PARC research laboratory was formed in 1970. In 1973, the laboratory developed the Alto computer, a personal workstation, which included a graphical interface and networking for sharing of resources. Several years later, in 1981, the first commercial personal computer was released – the Xerox Star. The Xerox Star, while allowing for little user tailorability, was based on early notions of usability engineering, including an iterative development process and techniques such as prototyping. The Star was closely followed by the Apple Lisa in 1983 and the Apple Macintosh in 1984; the Macintosh being the only product that found commercial success, largely due to lower pricing and the ability to build on the mistakes of previous attempts.

Equally importantly to technology developments in the growing field of HCI, Alan Newell was consulted in developing the initial program direction for Xerox PARC. In 1974, Newell, along with Stuart Card and Tom Moran, undertook a project to tie existing psychological theory and data to human-computer interaction. They
constructed the “MODEL HUMAN PROCESSOR” (MHP), a cognitive model of human skills, and the goals, operators, methods, selection rules (GOMS) methodology for deconstructing new tasks based in the process of designing interfaces. This framework allowed experts to conduct a quantitative prediction of user performance, and could be used to evaluate existing and proposed interfaces. These developments mark a concerted effort to apply existing psychological theory to HCI, with hopes of arriving at one, generalizable model of human cognition that would be relevant to design. In 1983, these ideas were published in what would become a classic work in the maturing field of human-computer interaction: The Psychology of Human-Computer Interaction (Card, Moran, & Newell, 1983). The early 1980s saw several other notable psychologists join in the formation of significant research groups such as: Card and Moran at PARC, Alan Newell at Carnegie-Mellon University; John Gould at IBM; Donald Norman at the University of California San Diego; Tom Landauer at Bell Labs, and John Whiteside at Digital Equipment Corporation (Grudin, 2005).

Yvonne Rogers, in her review of theoretical approaches for HCI, cites a general optimism during this period about the contributions of cognitive psychology to HCI claiming:

A driving force was the realization that most computer systems being developed at the time were difficult to learn, difficult to use and did not enable the users to carry out the tasks in the way they wanted. The body of knowledge, research findings and methods that made up cognitive psychology were seen as providing the means by which to reverse this trend, by being able to inform the design of easy to learn and use computer systems. (Rogers, 2004, pp. 90-91)
Rogers’ description emphasizes both the growth in discretionary use and a focus on “easy to learn and use” systems, while allowing users flexibility in pursuing these goals. This is a far cry from earlier human factors work directing the design and placement of buttons and switches to improve efficiency and precision of human operators in the workplace. As Liam Bannon states, “what was required was a better cognitive coupling between the human and the new universal machine, the computer, and not simply better designed surface characteristics of displays” (1991, p. 33). This attention to the human aspects of design pursued the goals of ease of use and user friendliness, both of which would become commercial selling points as it would become increasingly difficult to quantify the success or failure of discretionarily-used systems.

As the field continued to coalesce, the first Computer-Human Interaction (SIGCHI) conference took place in 1982; it had evolved and split off from SIGSOC, a group focused on the use of computers in social science research. The split reflected a fundamental reorientation towards “people-oriented computers” and away from “computer-oriented people” (Borman, 1996). The newly incepted research teams, and subsequent generations of graduate students, began to build a body of human-computer interaction literature and methodology strongly driven by cognitive psychology. Rogers classifies this application of cognitive psychology to HCI into three approaches: applying basic research within a controlled laboratory setting, cognitive modeling of human goal-pursuing behavior, and the diffusion of popular concepts throughout the field. These popular concepts largely originated from cognitive psychology and provided the field of HCI with explanations of the
capabilities and limitations of users in areas such as memory, attention, and decision making (e.g. George Miller’s theory of memory) (Rogers, 2004).

Rogers (2004) cites influential cognitive models of this period: Hutchins, Hollan and Norman’s (1985) conceptual framework of directness and Norman’s (1986) theory of action. Hutchins, Hollan and Norman (1985) explored direct manipulation interfaces, the benefits of which were described by Shneiderman (1982, p. 251); in direct manipulation interfaces, the complexity of interaction was muted by the use of continuously represented items that the user could manipulate graphically or physically without knowledge of syntax or programming. Hutchins et al. sought to further understanding of this feeling of directness, which they defined as an unquantifiable “feel” or impression about an interface, through the dimensions of distance and engagement. Distance measured the translation space between the user’s thoughts and the physical requirements of the system, while engagement marked the qualitative feeling of manipulating the necessary items (Hutchins, et al., 1985). Norman’s theory of action (Norman, 1986) expanded upon the concept of distance; he described the seven mental and physical stages a user progressed through in execution and evaluation of movement towards a goal. He presented the gulf of execution and gulf of evaluation which, respectively, described the distance between the user’s intentions and allowable system actions and the distance between the system’s representation of state and the user’s expectations. These theories yielded a series of questions to be employed during the design process in evaluation (Norman, 1988).
The qualitative aspect of engagement, the “feeling of involvement directly with a world of objects rather than of communication with an intermediary” (Hutchins, et al., 1985, p. 332), proved harder to understand in a predictive and useful manner. In pursuit of the feeling of engagement, the designer was tasked with creating an illusion or “world” within which the user would interact, and the beginnings of guidelines towards this state began to emerge (e.g. swift feedback and continuous representation of system state).

Cognitive psychology was not the only field of psychology contributing to HCI during this period; the field of ecological psychology had gained relevance as well. Ecological psychology was developed in the 1970s by J. J. Gibson (1979) who took the then-radical view that environmental information guided the behavior of animals, more so than that of internalized cognitive representations of the world, and that perception was tightly coupled to physical action. Gibson developed his theory of affordances, or the innate ability to perceive what the surrounding environment affords (e.g. shelter, food), based on the composition and layout of environmental surfaces. These affordances held value and meaning that could be directly perceived, i.e. these perceptions were external to the viewer. This focus on environmentally-provided affordances and constraints was applied to the field of HCI by Norman (1988), as he began to explore the ways in which the design of interfaces could encourage or constrain certain actions or perceptions of the user.

The cognitive modeling approaches that evolved during this period (e.g. Model Human Processor, GOMS, directness, theory of action) remained the prevailing
approach for many years. They eventually gave way to a more situated, evolving view of human interaction, as computers moved from the workplace, into the more complex environments of our daily lives and our homes – all complex use time scenarios not easy or even possible to model.

### 2.3 Users as Active Agents: Human Actors

By the 1980s widespread use of personal computers sparked tremendous interest in what would emerge as the human-computer interaction community. This work was very much in what Bødker (2006) calls *first wave HCI*. Usability was the primary focus of both researchers and practitioners. And, *usability*, was understood to involve one person interacting with one system to do one thing.

In *second wave HCI*, which Bannon (1991) described as the move from *human factors to human actors*, the focus shifted to groups of people, typically in established communities of practice, working toward common goals but with a collection of applications. Communication and collaboration became key topics for research and practice. While design theorists and HCI professionals were largely separate communities at this time, they did share a focus on collaboration. For example, Rittel (1984) proposed formalisms to help resolve what he saw as the *symmetry of ignorance* in urban planning; Ehn (1989) focused on ways to involve users in design efforts; and Rasmussen et al (1994) focused on *sociotechnical* systems such as nuclear power plants, where collaboration between people is key.

This focus on users as active agents, engaging collaboratively and communally, begins to take the focus of design out of constrained work environments and into
those of complex use time. Designers began to consider the myriad interactions (some predictable and some unforeseen) taking place in the environment in which their systems would ultimately live. It is around this time that of the beginnings of widespread use of personal computers, when the divide between design time and use time broadens considerably. Usability marks one movement towards participatory design, but it was still highly bounded in time and place. Building an understanding of real-world environments of use was instrumental in driving the next generation of HCI methodology and theory.

2.3.1 Situated, Emergent Environments of Use

During this time period, the real-world environments of technology use increased in complexity and also in unpredictability. Designers could no longer predict in advance and design for specific and constrained environments of use. These complex contexts of use and unanticipated uses in the hands of end users were a challenge for designers to support. The designers were increasingly distanced in time and in space from these use time scenarios. New approaches to understanding and describing the context of use began to emerge, intended to build our understanding, as designers, of the environments of use in which our technologies would ultimately live.

In 1987, Lucy Suchman’s published dissertation, Plans and Situated Actions (1987), proposed an alternate view of human-computer interaction in her theory of situated action. Informed by a social science and ecological psychology perspective, Suchman refuted the prevailing cognitive psychology belief that human behavior is
purposeful and planned, rather she argued that human action is more shaped by the immediate, surrounding contextual environment and circumstances. As briefly mentioned earlier, her theories arose from early 1980s workplace observations of employees using newly installed Xerox copy machines that were generating significant complaints. Using the time-honored anthropological technique of field studies, she noted, among other problematic findings, that workers had been distanced from the site of production and this distance yielded difficulties of interpretation once the system was installed in the setting of use (Suchman, 1997).

Also during this time period, Winograd and Flores began to dissect the role of expert systems in their influential book *Understanding Computers and Cognition* (Winograd & Flores, 1986). The dominant tradition at the time described human cognition as based on manipulating internal representations; this understanding was mirrored in computer programs that manipulated abstract representations of the world. Winograd and Flores claimed that such computer programs, or artificial intelligence systems, could never function successfully as real-world human cognition was not, in fact, based on manipulating internal representations. Similar to Suchman’s ideas of situated problem-solving, Winograd and Flores maintained that human cognition is based on an interpretation of the current situation, based heavily on our prior experience with similar scenarios. Expert systems simply could not model such a process, as it would necessitate a continuing adaptation to the changing interactions over time.
And from the cognitive engineering side in the late 1980s, Kim Vincente and Jens Rasmussen developed their ecological interface design framework (Rasmussen & Vicente, 1989; Vicente & Rasmussen, 1992). Arising from Gibson’s environmental theories, Vicente and Rasmussen’s approach focused on supporting human system operators during unanticipated events in highly complex work domains. Their eventual framework for cognitive work analysis (Vicente, 1999) had its origins in a Danish research program that was exploring the potential for effective implementation of nuclear power within the country; Jens Rasmussen, as head of the safety committee, began researching hardware reliability and failure data in order to construct probabilistic mathematical models determining safety. Despite multiple redundant safety systems, accidents continued to happen and a review of accident cases in multiple industries revealed that workers played a key role in system safety and that accident-causing errors were triggered by unfamiliar situations that were not anticipated by designers.

In response to these findings, the research team installed a prototype control system that could be observed in real-life situations, and sought to understand the adaptive nature of human problem solving through a decision-making model that represented the steps of reoccurring decision tasks. Their skills, rules, knowledge (SRK) framework categorized the ways in which people can interact with their environment, and provided a taxonomy for models of human performance which led to future research and use within the field of cognitive engineering (Vicente, 1999). This research tract had several key contributions: the problems addressed arose from real life use and not from theoretical laboratory experiments, there was a focus on the
inability of designers to predict all future use conditions, and a focus on field studies over quantitative analysis.

It was becoming increasingly apparent that “basic science” findings in the lab could not necessarily be generalized to use, as in Vannevar Bush’s linear model from basic to applied science. Not all early HCI researchers thought that a quantitative, predictive model of human behavior could be extracted and applied in interface design and a tension was building between cognitive theory and the needs of the applied designer.

2.3.2 The Unsolved Problem of Designing in Use

The frameworks oriented around understanding emergent interactions, focused on the behavior and actions of users in real-world environments of use with the goal of building or improving systems to support these needs. While end users were the focus of such approaches, they served to inform the researchers of their needs primarily through researcher observation or assessment of the existing environments of use.

In contrast to this approach focused on understanding emergent environments of use, a strong Scandinavian tradition and body of research had been building since the 1970s, with user participation as the focal point of design. A cultural emphasis on collective resources and multiple union-driven projects had dictated the inclusion of workers in the design and development of workplace computer applications. The Scandinavian active research approach stressed the “active cooperation between researchers and those being researched, suggesting that researchers need to enter an
active commitment with the workers of the organization to help improve their situation” (Bødker, 1996, p. 218). Early participatory design efforts, such as the Norwegian Iron and Metal Workers Union project, explored means of involving users directly in shaping technology solutions, at first through education and traditional research methods. Later union-driven projects (e.g. Utopia, NLIS’ AT project) moved towards the experience-based participatory techniques that characterize the approach today.

In a 1991 Scandinavian collection of writings oriented around cooperative system design (Greenbaum & Kyng, 1991), Henderson and Kyng put forth several ideas towards a future of designing in use (1991). They described the key challenges of design as arising from the differences between the setting of design and the ultimate setting of use. Design, in their view, should address: changing situations of use, the complexity and unpredictability of the real world, and the need to design for many different situations of use. This would be achieved through designing for tailorability, which focused largely on building technology and architecture to support user-driven modification during the design process, i.e. creating the artifact with change in mind. Henderson and Kyng (1991) identify three activities which characterize modifiable software: choosing between alternative anticipated and designed-for behaviors, constructing new behaviors from existing pieces or smaller parts, and altering the artifact itself (the most radical sort of change).

Building on a 1987 paper by Trigg et al. exploring adapting and tailoring a hypertext system (Trigg, Moran, & Halasz, 1987), Henderson and Kyng (1991)
suggest four desired properties of adaptable systems: *flexible* in that it contains objects that the user can interpret in different ways through use, *parameterized* in offering a range of behaviors to choose from, *integratable* so as to be used in a construction set, and *tailorable* in allowing the user to change the behavior of its parts through construction, adding functionality and specialization. These goals and principles differ from those of adaptive systems, in which the system dynamically adapts itself to the user’s needs; tradeoffs exist between the two approaches, such as the distribution of work between user and system, location of knowledge and user skill required for use (Fischer, 1993). Henderson and Kyng note several challenges to applying their adaptable system ideas to real life design problems, including the potential for greatly increased development effort, a steep learning curve, more time consuming use, and possible end-user disinterest in playing the role of “tailor”. They present a few workplace examples where developers work closely with users to make changes to issues arising through use, generally to alter small functional elements of the system, and advocate for a process of design and architecture that is created with change in mind. They offer little in the way of prescriptive design methodology, but looked forward to the fledging technique of object oriented design as a way to bridge the gap between developers and end users involved in real life work practices (Henderson & Kyng, 1991).

This gap, or “counterproductive barriers between programming and using programs” (Fischer & Girgensohn, 1990, p. 183), was a long-time concern of Gerhard Fischer’s research on *end user modifiability*. Fischer explored the “monopoly” maintained by skilled computer programmers over the end users of the system, and
how this might be overcome so that the ones closest to the problem, the users themselves, might be empowered to design their own solutions independent of “high-tech scribes” (Fischer, 2005). In a world full of unpredictable and unanticipated use, Fischer suggested that the logical solution was to allow users to function as designers, although this was not easily achieved from a technological perspective. In the 1980s and early 1990s, Fischer began exploring the potential of convivial systems; conviviality was a concept developed in 1973 by Ivan Illich in *Tools for Conviviality*. A forward-thinking and (arguably) radical theorist, Illich put forth a social critique of the role of technology, claiming that modern technologies should “serve politically interrelated individuals rather than managers”, support creative, autonomous, design actions by individuals rather than institutions, and “give each person who uses them the greatest opportunity to enrich the environment with the fruits of his or her vision” (Illich, 1973).

In pursuit of the goal of technological conviviality, Fischer explored systems that allowed users to carry out a constrained design process within the boundaries of modeled domain knowledge (e.g. Fischer & Girgensohn, 1990; G. Fischer & Schneider, 1984). In contrast to the more theoretical work addressing the subject of users as designers (e.g. Henderson & Kyng, 1991), Fischer used knowledge-based design environments as prototypes to illustrate his conceptual framework of *end-user modifiability*, developing systems such as JANUS for architectural design (Fischer & Girgensohn, 1990). These *domain-oriented design environments* (DODEs) provided a design space for individuals empowered to create, critique, and reflect upon design solutions, while guided and supported by the structure of domain knowledge (Fischer,
1994). DODEs were highly dependent on a body of existing domain knowledge, and best practices; this knowledge base provided the initial structure within which user designs might evolve.

Fischer (1990) claimed end-user modifiability as desirable, especially in the context of highly evolving knowledge-based systems, in that it would empower end-users to change the behavior of the system within the context of the problem space and post-release. It did not suggest modifying or replacing the distinct roles of designer and user, rather allowing for and supporting a constrained user-motivated design process to better support users’ tastes and tasks. This approach acknowledged the evolution of design in use as a reality, as a natural and even desired outcome. This is in contrast to a more HCI-oriented view that post-release changes indicate failures of the design process or lack of attention to usability. Pressman, in a software engineering handbook, writes that one study “found that 80 percent of software life-cycle costs occur during the maintenance phase. Most maintenance costs are associated with ‘unmet or unforeseen’ user requirements and other usability problems” (Pressman, 1992). These “unmet or unforeseen” user requirements are exactly those which end-user modifiability attempts to support.

A focus on end-user modifiability was not without its own downsides; it did introduce additional cost during system development time and required modifiability to be an explicit goal in the original design of the system. Even with an understanding of these requirements and a focus on end-user modifiability, true evolutionary growth of such systems still required major updates by skilled
knowledge engineers, as in the “reseeding” phase of Fischer’s SER model. And development techniques to support end-user modifiability often carried the cost of reduced system reusability and portability.

2.3.3 Practical Processes of Design

In addition to the growing trend of user-involved design practices, a number of other researchers offered up criticisms of the prevailing cognitive approach. Olson and Olson (1990), in an review of the growth of cognitive modeling within the field of HCI, noted that while cognitive modeling may usefully inform early design it does not “extend to the broader aspects of the context in which people use computers” (p. 222) citing both gaps in theory and lack of application to more global questions (e.g. the role played by individual differences). Furthermore:

[Cognitive modeling] is not the type of model that will aid the designers in designation a set of functions the software ought to contain, to assess the user’s judgment of the acceptability of the software, or the change that could be expected in work life and the organization in which this work and person fits. (Olsen & Olsen, 1990, p. 223)

They do note that cognitive modeling techniques, such as GOMS, can be useful in: constraining the design space to fit known cognitive limitations, answering specific implementation design decisions, estimating task time, guiding training documentation, and knowing which stages take longest or result in the most errors. They suggest that another kind of modeling is required to address issues such as determining functionality, acceptance, and fit to organizational life.

In a 1991 position paper on the role of cognitive psychology in HCI, Landauer illustrates how ill-suited cognitive theory is to real life use; he describes “the problem
of complexity; so many things can happen in the interaction of a human with a machine that it is impossible to anticipate everything that can go wrong. It is hard to imagine any ‘theory’ that would help” (Landauer, 1991, p. 63). He went on to suggest limited use for some existing theories (such as Fitt’s Law), and advocated for relying more on empirical studies, in pursuit of a “usefulness-and-usability-oriented design discipline” (p. 67). Within the ongoing debate as to the place of theory within HCI, Carroll and Kellogg (1989) describe an emerging paradox within HCI research, wherein application often led theory, and not the other way around. They propose that the artifacts created by designers are embodied HCI theories, and that theories can be abstracted from the artifact itself. In a critique of these arguments, Bannon and Bødker claim that such activities cannot predictively contribute to designing novel artifacts as “the artifact reveals itself to us fully only in use” (1991, p. 237), therefore a study of the artifact in isolation reveals little of interest.

The limitations of the cognitive modeling approach to real life design situations had become very apparent and openly discussed (e.g. Gray & Atwood, 1988; Whiteside & Wixon, 1987), and Landauer was not the only one to call for a movement towards usability (e.g. Bannon, 1991). The work around cognitive modeling techniques like GOMS would not disappear; they would build momentum again in the late 1990s as technological advances afforded increased computer processing power and speed, and yielded increasingly powerful models. But it would remain restricted to work practices and tasks that were highly bounded, routine, and defined.
The early 1990s were characterized by an increased interest in cognitive modeling approaches viewed as more applicable to practice and in conducting empirical experiments with real users, under the umbrella term of “usability engineering”. The approach had evolved in the late 1980s, from the work of John Bennett at IBM and John Whiteside at Digital Equipment Corporation; they advocated for a practical engineering approach to design, in which techniques such as iterative prototyping were incorporated into the product design process (Whiteside, Bennett, & Holzblatt, 1988). In HCI, a field that was struggling to find a balance between theory and application to practice, these ideas set the stage for a dramatic increase in practical usability methods. Nielsen and Molich (Nielsen & Molich, 1990), citing a lack of formal analysis models useful to real product design, developed their version of heuristic evaluation, a streamlined series of guidelines to be followed by designers in identifying usability issues. Peter Polson and colleagues at the University of Colorado created the cognitive walkthrough out of their theories of exploratory learning (Polson & Lewis, 1990); the cognitive walkthrough was a methodology for design teams to explore the tasks a user must complete, broken down to a step-by-step level in order to identify potential issues (Polson, Lewis, Rieman, & Wharton, 1992). By 1993, Nielsen had published Usability Engineering (Nielsen, 1993), a practitioner-oriented handbook covering a series of usability assessment methods, and other exhaustive guides soon followed (e.g. Dumas & Redish, 1993; Rubin, 1994).

These usability techniques gained popularity quickly as they were pragmatic, prescriptive, and relatively easily communicated to design practitioners (who,
increasingly, were not the theorist and psychologists of the early days of HCI, but rather commercial designers outside academia). Many of the methodologies developed during this period remain in common use today, both in industry and academic settings. This rush to create techniques that were applicable to real life design scenarios left some researchers questioning their effectiveness. In 1998, Gray and Salzman (Gray & Salzman, 1998) reviewed several published experiments comparing usability evaluation methods and questioned their validity and effectiveness. Although the chosen studies were highly influential to HCI practitioners at the time (and to a lesser extent, theory), Gray and Salzman found them to be rife with flawed study designs, misleading presentation of results, a lack of generalizability and reliability, authors who “went beyond their data” to offer advice, among other issues. Perhaps most importantly, they provide a reminder that the goal of usability is to improve the “outcomes of interest” (which could widely vary depending on the type of product being developed) and that there is still a lack of empirical work proving the connection between improved usability and improved usefulness of the eventual product.

2.4 A Return to Designing in Use: Human Crafters

In Bødker’s (2006) third wave HCI, “the use context and application types are broadened, and intermixed, relative to the focus of the second wave on work. Technology spreads from the workplace to our homes and everyday lives and culture.” She continues to note three challenges – (1) people need to be involved in design, not just as workers, but as someone who brings their entire life experience
into the design, (2) this will necessitate a change in the way we design and prototype, and (3) we need to move away from end-user programming in isolation to configurations involving multiple people and multiple systems.

Figure 2: Changing relationship between use time and design time

These recent changes illustrate a second iteration of human crafters. As detailed by Figure 1 above, the evolution of HCI can be described as shaped by a changing relationship between design time and use time. For many years, design and use were one and the same, those with the need acted as human crafters in designing their tools as they were used; industrialization introduced a divide between design time and use time and we entered a phase of human factors, where technology systems were created for constrained work environments close to the setting of
design. Following this phase, an influx of theory and methodology oriented towards understanding complex real world use recast users as human actors and involved them at design time in participatory techniques. This brings us to the fourth stage of Figure 1, where there is a return to human crafters. Design time and use time have drifted apart over the many stages of human evolution; in the present, design time and use time begin to come back together as end users once again act as crafters of their technological environments.

| Phases of the Field of Human-Computer Interaction (HCI) |
|-----------------|-----------------|-----------------|
| **1st Wave**    | **2nd Wave**    | **3rd Wave**    |
| Human factors   | Human actors    | Human crafters  |
| Focus of design activities |       |                  |
| Efficiently matching workers to machine interfaces | End users as active contributors to design activities and needs | End users begin to be empowered to mold technology in use |
| Context of design |       |                  |
| Known and constrained work environments | Discretionary use contexts – from the office to the home and daily life | Technology used in ubiquitous and rapidly changing contexts |

Like the earlier stage of human crafters, the goal is to reduce the separation between design time and use time. Unlike that earlier phase, we are designing for a world which is increasingly technological. Evaluating the usability of interfaces and observing and describing real-world use, although valuable techniques, could not predicatively inform design. The unanticipated futures of the technology when released in the world remained problematic; the new interactions it would facilitate
and the necessary changes and modifications that would arise through use were unknown.

Henderson and Kyng’s vision of “designing in use” was not the first to approach the problem of designing for unpredictable futures. These ideas were highlighted in earlier influential works: notably Christopher Alexander’s vision of an “unselfconscious culture of design” (1964) where users had the skills and confidence to tailor their environment, and Ivan Illich’s concept of convivial technology tools (1973) that would empower people to conduct creative and autonomous actions. These largely theoretical works described a fundamentally different culture of design, one which introduced complex questions around the goal of allowing and encouraging users to act as (and with) designers.

Although these ideas had been around for many years, the challenge of continuously designing in use was rapidly becoming unavoidable. In 2006, John Thackara, in writings centered around sustainable and complex design practices notes that “against this backdrop of situations in which systems don’t stop changing, the idea of a self-contained design project—of ‘signing off’ on a design when it is finished—makes no sense” (2005, p. 224). Bødker’s suggested “3rd wave” goal of “re-configurability in the hands of networks of human users” (2006, p. 5) was becoming not just a vision, but a requirement.

Many open questions exist around how to practically support users during the process of designing in use. Approaches tended to primarily focus on either anticipatory or participatory techniques, although the very nature of the idea – of
allowing users to design systems continuously in real-life use – necessarily blurred these boundaries. Anticipatory techniques explored what could be done at design time (often by designers alone) to endow the system with the properties to be flexible in use. Architect Stewart Brand’s process of scenario-buffered design (1994) encouraged users and designers to strategize around potential future uses for the building and space, yielding a final design that could respond well to multiple futures, not just the “official future” (see section 2.5.2).

In the field of information systems, Gerhard Fischer’s research has, for many years, explored how systems can be user modifiable such that they might be designed in use. Looking at both the anticipatory and participatory aspects, early work focused on building knowledge-based design environments (Fischer, 1994) (or DODEs) which provide a constantly evolving space in which users can create, reflect, and shape the system. Fischer’s Seeding, Evolutionary Growth, and Reseeding (SER) Model (Fischer, McCall, Ostwald, Reeves, & Shipman, 1994) attempted to address the changing nature of use as the system evolved. In this model, a participatory design (or co-design) process between environment developers and domain designers yielded a “seed” within which as much information as possible is designed. This seeded environment is then used by domain designers on real projects, allowing for evolutionary growth through system use, until it becomes unwieldy and the reseeding process, organizes, generalizes, and formalizes.

Fischer and Giaccardi, in more recent work (e.g. Fischer, 2007; Fischer & Giaccardi, 2006), address these issues and endeavor to take HCI beyond the
limitations of participatory design methods and towards a future of user-centered development or meta-design. Taking on many of the challenges inherent in Bødker’s “third wave” of HCI, meta-design describes a future state of design consisting of open systems that evolve during use, with design activities redistributed across time and levels of interaction with the environment. Their framework emphasizes that the design of socio-technical systems must support flexible and evolving systems, that are not (and cannot be) completely designed before use, and that evolve in the hands of their users. This approach attempts to leverage what we do know about design and its limitations: that we can’t anticipate future needs as they are changing and ill-defined, that solutions do not lie in one mind alone, and that the setting of design may differ greatly from the setting of use.

In attempting to shift design activities from “design time” towards “use time”, Fischer and Giaccardi (2006) suggest a number of dimensions that come into focus as distinctly different from traditional design concerns: process over object, co-creation over autonomous creation, seeding over complete system, construction over representation, and exceptions and negotiations over guidelines and rules, among others. Further diverging from earlier HCI techniques, meta-design suggests that designers must give up control to users and that users may play the role of consumers or designers depending on context (Fischer, 2007).

In practice, true meta-design methodologies that can be generalized across domains are not forthcoming. An attempt has been made to extract useful principles from identifying and exploring existing models of success, such as open source
software development as a model for distributed cooperative work, and to explore and explain from a meta-design perspective a variety of domains (e.g. interactive art (Giaccardi, 2004), digital libraries (Wright, Marlino, & Sumner, 2002), and learning communities (dePaula, Fischer, & Ostwald, 2001)). The vision of meta-design is far-reaching and deeply embedded in both social and technical issues, raising questions as to the nature and motivation of participation, the evolving practices of communities, and the limitations and capabilities of our technologies, among others; perhaps most importantly to this discussion, these questions cannot be asked or answered in the laboratory.

Furthermore, new modes of information production have arisen from highly influential technologies and infrastructures such as the Internet, with little direct involvement from HCI theory or practice. Yochai Benkler (2006), in *The Wealth of Networks*, describes how new information production models have emerged in the increasingly ubiquitously networked environment, as the physical costs of information production declines through widespread computer networks. *Commons-based peer production* (Benkler, 2006) describes the efforts of thousands of individual volunteers, exploiting computer infrastructures such as the Internet, in order to collaborate, organize, and cooperate on immensely powerful, creative, and popular information products and systems (e.g. Wikipedia, Apache web server). Few of these developments involve formal usability methods or qualitative techniques; these projects arise for and by users’ own actions, playing the fluctuating role of both designers and users. Moving closer to Ivan Illich’s dream of “convivial tools” (Illich, 1973), these new production frameworks allow individuals to freely enrich their
environments with their creative efforts. These new developments also bring us closer to Henderson and Kyng’s vision of a future of systems that are designed in use.

2.5 Designing for Design in Use

Designing for “design in use” requires design time thought to be focused away from immediate needs and towards common emergent behaviors that users engage in over time. These behaviors center around: connecting – to people with similar interests or needs, having conversations – in real-time across space and time, combining – the system with other tools and systems they use, getting up to speed quickly – so undue time is not spent learning the system, and tailoring – such that the system is molded to their personal needs. These emergent behaviors create a highly complex “use time” in which designed systems may be used in a myriad of unanticipated ways. Although many theoretical theories and frameworks increased our understanding of the complexities of context (e.g. Dourish, 2004) there was still a gap between theory and practical support for such emergent behavior.

2.5.1 Understanding the Complexities of Use Time

As this history of HCI has illustrated, the field has moved away from the basic science laboratory and firmly into real life practice. As Gray and Salzman illustrated, there was still relatively little understanding of how to improve system design in a measurable, useful way. Donald Schön (1983) notes that the problems with the highest relevance and social importance may be those in which it is hardest to obtain technical rigor; the field of HCI struggled with this issue as it moved away from the laboratory. As mentioned earlier, Gibson’s ecological psychology (Gibson, 1979),
Vincente and Rasmussen’s cognitive work analysis (Vicente & Rasmussen, 1992), and Lucy Suchman’s situated action (Suchman, 1987) were developing theories suggesting a shift in design towards the environment and setting of use. Theories from other nearby fields were being incorporated into HCI as well, as the movement away from cognitive psychology continued: Activity Theory emerged from Soviet psychology (Engeström, 1987), external cognition from Scaife and Rogers (Scaife & Rogers, 1996), distributed cognition from the anthropological work of Ed Hutchins (1995), and Card and Pirolli’s information foraging (Pirolli & Card, 1999). These newer approaches yielded rich, explanatory descriptions, with a focus on providing formative, generative, and analytic frameworks (Rogers, 2004). Bodker describes these methodological and theoretical shifts as characterizing a “second wave” of HCI (see section 2.3 and Table 1, above):

In the second wave, focus was on groups working with a collection of applications. Theory focused on work settings and interaction within well-established communities of practice. Situated action, distributed cognition and activity theory were important sources of theoretical reflection, and concepts like context came into focus of analysis and design of human-computer interaction. Rigid guidelines, formal methods, and systematic testing were mostly abandoned for proactive methods such as a variety of participatory design workshops, prototyping and contextual inquiries… (Bødker, 2006, p. 1)

With newly minted theories and methodologies, the majority of them qualitative in nature, HCI gained new ways of describing and understanding use as it happened in real life. There was often little connection between these theories and predictive design methodologies for practitioners to employ. In a study exploring practitioners use of theory, Rogers (2004) found that while concepts (e.g. affordances) were well known, analytic frameworks (such as those of Activity Theory or distributed
cognition) were too difficult to employ in applied design, and the influx of competing theories further complicated potential application. Rogers notes that a great number of practical methods and techniques had emerged from the research oriented around usability, suggesting an increasing divide between practitioners and researchers in the field of HCI. These usability-oriented practical methods would remain continuously popular through to present day HCI, with much effort in education and industry dedicated to learning and employing such techniques.

As we increased our knowledge of how to do design and describe use, the explosion in technology left researchers questioning the role of computing as devices and tools became increasingly ubiquitous. Landauer (1995) describes two overlapping phases of computing, the first being automation, where computers were primarily tasked with “chores” needing no human involvement or beyond human capabilities (such as complex numeric calculations), and the second being augmentation, a far more complex challenge. John Thackara cites the ongoing struggle between people and automating technology: “from nineteenth-century mill owners to twentieth-century dot-commers, businesspeople have looked for ways to remove people from production, using technology and automation to do so” (Thackara, 2005, p. 4).

In the augmentation phase of computing, Landauer claimed that computers would assist in a wide range of duties that could not be completed solely by machines (e.g. write, read, create art, etc.) From the vantage point of 1995, Landauer cited the decline of the first automation phase and the emergence of the augmentative focus,
and weighed in on the current “trouble with computers” as relating to the complexities of augmentative systems dealing extensively with human operators. Such systems required a great deal of unstructured and unpredictable interaction with humans, forcing programmers to attempt to predict (and code for) a myriad of human responses and actions. It is in these systems, Landauer claimed, that the performance and effectiveness of computing began to yield diminished returns, leading to a productivity paradox with no obvious solution (and no clear solutions from the field of HCI).

And on an organizational level, Hammer (1990) cautioned against simply using computers to automate existing work processes or “rearranging deck chairs on the titanic”; automation efforts often recreate organizational processes that stifle creativity and innovation and should be reevaluated entirely. Fischer describes this process as a “gift wrapping” approach, in which technology simply extends existing practices instead of providing a cataclysmic opportunity to rethink future scenarios and systems (Fischer, 1998). Brown (1991) suggested a “pioneering” research approach with new organizational principles devoted to learning from local, innovative work practices and moving towards the co-production of innovation with the customer. Although participatory design had begun to pave the way for including customers in the process of design, Brown took these concepts further, suggesting a future in which information technology is rendered invisible: “information technology will become a kind of generic entity, almost like clay. And the ‘product’ will not exist until it enters a specific situation, where vendor and customer will mold it to the work practices of the customer organization” (1991).
2.5.2 Is Participatory Co-Design Possible?

These idea of co-design was gaining momentum in participatory design practices wherein users and designers worked together to envision future contexts of use. As earlier researchers had cautioned (e.g. Fischer & Girgensohn, 1990; Henderson & Kyng, 1991) design time processes still could not capture all the complexity and possibilities of real-life use time. The field of HCI was not the only one struggling with the dilemma of designing for a largely unknown future of use; the architect Stewart Brand (1994) proposed a process of scenario buffered design in which designers strategize around potential future uses, seeking to avoid “making the building all too optimal for the present and maladaptive for the future” (Brand, 1994, p. 181). He proposed the unit of analysis of design to be not simply the building itself but rather the use of the building throughout time. In this “future oriented process of design and decision” (Brand, 1994, p. 181), he advocated for a participatory process focusing on scenario creation exercises, beginning with identifying the driving forces that will shape the future and extending these into the “official future” and a number of implausible, but possible, other scenarios. In this tactic, an unpredictable future is assumed, but in theorizing around divergent scenarios, adaptability and flexibility are naturally built into the design. Similar to Fischer, Brand suggests shifting design power to the user, in creating buildings that afford easy servicing by the users and opportunities to develop a hands-on relationship with “their” space.

Christopher Alexander’s ideas, too, rested upon that assumption that “it is simply not possible to fix today what the environment should be like twenty years
Alexander’s architectural patterns languages (Alexander, 1975; Alexander, 1979) took a different approach to the problem of design evolution over time; his patterns, or general planning principles stating a problem, appropriate contexts and solution, were oriented towards incremental development designed by users and across long periods of time. A shared understanding of these principles led to the piecemeal creation of consistently usable and appealing spaces, with coherence throughout the community. Alexander emphasized the importance of end-user contributions to design within such a process: “I believe passionately in the idea that people should design buildings for themselves. In other words, not only that they should be involved in the buildings that are for them but that they should actually help design them” (Alexander, 1984). This was not easily achieved and relied heavily on successful negotiation of the “problem of rigidity”; plans must be rigid enough to suggest the critical relationships between buildings, yet flexible enough to guide and shape the details around individual buildings.

Although pattern languages in computer systems development emerged from Alexander’s concepts during the 1990s (e.g. Gamma, Helm, Johnson, & Vlissides, 1995; Tidwell, 1999), they were oriented towards solving specific implementation problems or to facilitate code reuse and programming style. The “quality without a name” pursued by Alexander was out of reach of computer systems, in that it could not easily be defined or directly addressed. Ivan Illich claimed that “people have a native capacity for healing, consoling, moving, learning, building their houses, and
burying their dead” (1973, p. 54); it is this natural, native capacity for building that Alexander claims has become a forgotten art and which is embodied in his pattern languages. In the context of computing, it becomes much less clear how to create and orient pattern languages, and they ultimately served a very different purpose than those of Alexander’s.

2.6 Meta-Design: Conceptual Framework

In the field of HCI, with the influx of theories emphasizing the situated, constructed nature of human problem solving (e.g. situated action, distributed cognition) and the shift of methodology towards the qualitative description of use, the unit of analysis for design has formally expanded to include the environment of use. The understanding of this use time was grounded in the immediate situation, and not usefully predictive about future scenarios. There was building evidence that usability techniques alone could not ensure future design success and that important, but little understood dimensions were emerging (e.g. the emotional or affective value of systems). In an increasingly technologically complex world, traditional usability methods were faring poorly. Greenberg and Buxton (2008) reflect on the history and application of usability evaluation, claiming that such techniques can stifle early innovation and focus on yielding only one “right” design. They suggest developing methods for measuring more important characteristics, such as utility and cultural adoption over time, to address new design challenges (although there is little guidance as to how to actually apply such ideas).
Bødker (2006) describes this “third wave” of design as challenged with: broadened use contexts and application types, technology spread across both the workplace and home life, and attempts to integrate culture, emotion, and experience into design. She claims that “the second and the third wave seem to be stuck on either side of the divide between work on the one hand and leisure, arts, and home on the other; between rationality on the hand and emotion on the other” (Bødker, 2006, p. 6). Bødker advocates for change, claiming that second generation methods require further development in confronting the challenges of: multiplicity of interaction of computing devices, changing use contexts, and experience and reflexivity; suggesting 1) users bring their “entire lives” to participatory design, 2) new technological approaches to understanding appropriate questions to ask, and 3) integrating tailorability research in tackling new complexities of use (Bødker, 2006, pp. 2-6).

John Thackara (2005) suggests a series of design frameworks for action in an increasingly complex world, focusing on: sensing and responding, sensitivity to deep context, seeding edge effects where change is most fluid, smart recombination of organizations and existing tools, designing with (not just for) people, pursuing design opportunities that enrich daily life, and approaching design as a service, not just a project (pp. 213-224). Perhaps most troubling to existing HCI practices, Thackara notes that “against this backdrop of situations in which systems don’t stop changing, the idea of a self-contained design project—of ‘signing off’ on a design when it is finished—makes no sense” (2005, p. 224).

Fischer and Giaccardi (Fischer & Giaccardi, 2006; Giaccardi & Fischer, 2008), in more recent work, address these issues and endeavor to take HCI beyond the
limitations of participatory design methods and towards a future of user-centered development or *meta-design*. Taking on many of the challenges inherent in Bødker’s “third wave” of HCI, meta-design describes a future state of design consisting of open systems that evolve during use, with design activities redistributed across time and levels of interaction with the environment. Their framework emphasizes that the design of socio-technical systems must support flexible and evolving systems, that are not (and cannot be) completely designed before use (i.e. systems must be underdesigned), and that evolve in the hands of their users. This approach attempts to leverage what we do know about design and its limitations: that we can’t anticipate future needs as they are changing and ill-defined, that solutions do not lie in one mind alone, and that the setting of design may differ greatly from the setting of use.

In attempting to shift design activities from “design time” towards “use time”, Fischer and Giaccardi (2006) suggest a number of dimensions that come into focus as distinctly different from traditional design concerns: process over object, co-creation over autonomous creation, seeding over complete system, construction over representation, and exceptions and negotiations over guidelines and rules, among others. Further diverging from earlier HCI techniques, meta-design suggests that designers must give up control to users and that users may play the role of consumers or designers depending on context (Fischer, 2007). Meta-design situates design within the context of problem solving, while supporting the inherent improvisatory, evolutionary, and participatory nature of human design.
Meta-design does build on earlier approaches such as participatory design (Schuler & Namioka, 1993), which (as discussed previously in section 2.3.2) focuses on co-designed systems in which end users play an active role in forming an understanding of the problem space and final designed solutions. Participatory design does not emphasize end user involvement over the life of the system, as in meta-design, and end users do not play the role of system designer over time. The user-centered design (UCD) (e.g. Norman & Draper, 1986) approach has similarities to meta-design as well, in that UCD attempts to build a rich understanding of end user needs and build systems suited to these goals. Meta-design seeks to understand user needs such that a minimal system “seed” (Fischer, et al., 1994) may be created and the necessary tools for end users provided, but this approach is focused on creating a space for others to shape in the future and not creating a completed design artifact, as in UCD.

Each design approach places a different emphasis on who is responsible for design activities (i.e. system designers or end users) and where the focus of design activities lies (i.e. in meeting present needs or future contexts). Each approach contains a number of design methods aimed at building an understanding of end user needs and the contexts of use. For user-centered design, this includes techniques such as personas, scenarios, use cases, heuristic evaluation and cognitive walkthrough (Rogers, Sharp, & Preece, 2011); each of these techniques is oriented towards contributing towards or iteratively improving some aspect of the design. Typically such methods are used in combination, depending on the goals, resources, and skill sets of the design team.
The figure below explores how these methods are placed in relation to *design specificity* – how specific are the design suggestions? – and *design responsibility* – who is responsible for designing and evolving the system? This assists in illustrating what contributions are made by each technique and what aspects of design are addressed. The meta-design inspired guidelines, which will be discussed in greater detail in the research methods section of Chapter 4, are also placed on the diagram, to represent the potential contribution such a meta-design inspired process can make to our existing design methods.

![Diagram: Design specificity and responsibility in common approaches](image_url)

**Figure 3: Design specificity and responsibility in common approaches**
As detailed in figure 3, above, meta-design has provided a SER model to link design time and use time. In addition to the previous work on DER and DODEs, an attempt has been made to extract useful principles from identifying and exploring existing models of success, such as open source software development as a model for distributed cooperative work, and to explore and explain from a meta-design perspective domains such as interactive art and learning communities. Recent work by Fischer and Hermann (2011), has identified the following key guidelines for the meta-design of socio-technical systems: provide building blocks, underdesign for emergent behavior, establish cultures of participation, share control, promote mutual learning and the support of knowledge exchange, and structure communication to support reflection on practice. A key principle for the meta-design of socio-technical systems, included in this series of guidelines, is to provide building blocks for the eventual end users of the system to “freely combine, customize, and improve these components or ask others to do so” (Fischer & Herrmann, 2011).

This principle offers a natural connection to practical meta-design methods that can bridge the gap between theory and practice in this area; taking inspiration from such meta-design principles and moving them towards practical techniques.

2.7 What’s next for HCI?

In *The Invisible Computer* (1998), Donald Norman addressed the fundamental (and in his view – inescapable) complexity of computing devices; the more functionality computers were tasked with, then the more complicated and hard to use they became. No amount of designing could remedy this situation and the
relentlessly evolving business model of the PC industry forced continuous change. Similarly, Bill Buxton (2002) notes that while human capacity remains constant, technology offers continuous growth in functionality, leading to a future in which technology passes the “complexity barrier” and exceeds human capabilities.

Using the evolution of motors found in common household appliances as a model, Norman describes how motors became “embedded within these specialized tools and appliances so that the user sees a task-specific tool, not the technology of motors” (Norman, 1998, p. 56). He advocated for a movement towards information appliances which perform specific information-related activities, fitting to the task exactly, and provide universal communication and sharing. Norman’s vision rests upon the free sharing of information, and, he claimed, yielded two primary benefits: the power of serendipitous flexibility and the avoidance of monopolistic control (Norman, 1998, p. 65). Written from the vantage point of 1998, the power of computing beyond the desktop was gaining steam; information appliances were starting to be technologically achievable, especially in respect to the freely shared information and communication channels required. In 2001, Buxton (2002) extended these ideas, describing the properties and tradeoffs of “super appliances” designed with attention to physical and social context, as well as relative to other information appliances.

In today’s information environment, the nature of technology tools has evolved towards Norman’s vision of information appliances; in a typical day we encounter and interact with multiple computer-processor-powered artifacts. The
popularity of the ubiquitous computing research theme continues to build in tandem with such tools. This multiplicity of interaction is a key challenge defining the 3rd wave of HCI, as described by Bødker. A rift between HCI application and theory has emerged as a result of these advances; technologies have begun to enable quick and easy changes pieced-together during use, which is not reflected in our design techniques.

In the early days of HCI, technology was relatively scarce, expensive, and intentionally designed. It arose from a constrained development process within which designers could evaluate interfaces, and this was extended to multiple, iterative evaluations informed by observations of real-life use as the field (and technology) evolved. In recent years, technology has become cheaper, more widespread, and flexible; this has yielded brand new modes of information production and behavior, such as Benkler’s commons-based development. These means of information production are fundamentally different from traditional commercial product development, in user motivation, distribution of design power, self-organization, and rapidity of change.

HCI still operates within a traditional model where design time and use time are separated. Even though this distance may be minimized, such as in participatory and scenario design techniques, it still exists and it still divorces the resulting tools from the complexities of real life use; in the words of Stewart Brand it “over-responds to the needs of the immediate needs of the immediate users” (1994, p. 181). There is still a “time out”, however brief, when technology tools go back into the hands of the
designers to be modified. Approaches such as Fischer and Giaccardi’s meta-design attempt to confront this distance directly, but need further exploration to provide generalizable methods and not just theory. As this dissertation begins to explore, these challenges suggest redirecting our attention towards bridging the gap between design time and use time by focusing design time thinking on unpredictable use time futures, in a continuous and participatory manner.
3. RESEARCH QUESTIONS

This section will detail the guiding research question as well as the series of four research questions that will be explored in this research study. This chapter is structured as follows:

3.1 Introduction and Guiding Research Question

3.2 Research Questions

3.2.1 Research Questions 1-A and 1-B: Effect of meta-design inspired idea generation process and end user participation on idea generation

3.2.2 Research Questions 2 and 3: Meta-design in continuous, participatory real-world design activities

3.1 Introduction and Guiding Research Question

As explored in the review of literature, the divide between design time and use time evolved over history in tandem with our technology and design processes. In today’s world of increasingly customizable technology and “hands-on” culture, we see a return to human crafters – end users willing to shape and modify their technologies in use. Research on meta-design suggests continuous co-design as a solution to these problems; there is little practical advice for the next generation of meta-designers.
Meta-designers must use new tools and techniques to focus their design-time thinking on future scenarios of use, and this conversation will happen with end users continuously over time. In support of this future of design, the proposed experiments seek to focus design time thinking on addressing unpredictable use time futures, in a participatory manner and in pursuit of the guiding research question:

\[ RQ_{GUIDING}: \text{Knowing that future use can never be entirely anticipated, are there techniques that can help anticipate some use time possibilities at design time?} \]

This guiding research question attempts to bridge the gap between design time processes and unpredictable future scenarios of use. This guiding research question is further decomposed into the four operationalized research questions that follow.

3.2 Research Questions

The following four research questions address several key factors in the guiding research question, in pursuit of moving design processes closer to use time. Each question is further explored in the following sub-section.

\[ RQ1-A: \text{What is the effect of meta-design inspired guidelines on the design ideas generated during design activities?} \]

\[ RQ1-B: \text{What is the effect of end user participation on the design ideas generated during future-focused design activities?} \]

\[ RQ2: \text{Can meta-design inspired guidelines provide a useful framework for focusing continuous and participatory real-world design time activities on future scenarios of use?} \]
RQ3: What types of changes might end users want to make to systems during real-world use?

3.2.1 Research Questions 1-A and 1-B: Effect of meta-design inspired idea generation process and end user participation on idea generation

In a world in which system design is continuously evolving, designers must anticipate, as much as possible, future scenarios of use and future needs of end-user designers. This is a fundamentally new perspective on design and the role of the “official” designers. In successful meta-design systems, the work of the designers is intentionally incomplete, allowing for the efforts of future designer/users. Research questions 1-A and 1-B explore the roles of meta-design inspired guidelines and end-user participants in such a process. These questions and the resulting experiments, explore design-time ideation and the role of these factors in shifting this design-time thought to tools and features allowing future end-users to shape the system to their needs in use:

RQ1-A: What is the effect of meta-design inspired guidelines on the design ideas generated during design activities?

RQ1-B: What is the effect of end user participation on the design ideas generated during future-focused design?

These research questions, explored in a laboratory setting, help describe the basic effect of including end users in design processes as well as the effect of using meta-design inspired guidelines on design-time ideation. The results of the ideation
exercise can then be evaluated against the goals of meta-design – to provide flexible, modifiable systems for future end user designers.

3.2.2 Research Questions 2 and 3: Meta-design in continuous, participatory real-world design activities

Meta-design systems are inherently continuous – design never stops – and participatory – users contribute to system design in an ongoing co-design process. Both of these activities are tied to real-world contexts and longitudinal real-world timeframes. The above research questions will explore the basic applicability of the meta-design inspired guidelines, but meta-design cannot happen in a laboratory. The following research questions begin to explore meta-design systems in the context of real world design and use:

*RQ2:* Can meta-design inspired guidelines provide a useful framework for focusing continuous and participatory real-world design time activities on future scenarios of use?

*RQ3:* What types of changes might end users want to make to systems during real-world use?

In pursuit of moving these concerns closer to real-world use, these research questions will be explored with real-world design teams over time, in an ipl2 design exercise approach. As discussed in the review of literature, a useful exploration of meta-design must focus on how to practically focus meta-designers on future environments of use. While the first two research questions explore key factors to assess the usefulness of a meta-design inspired approach to design, these questions
must be expanded to address real-world contexts. Research questions 2 and 3, above, are of upmost importance in taking meta-design concerns closer to real-world use and real-world validity. Research question 2 explores the meta-design inspired guidelines in the context of a real-world design team working with end users, while research question 3 builds on our understanding of the types of changes future end users, such as these, might want to make to the system during real-world use. This brings our understanding of the meta-design framework closer to real-world use and practical application.
4. RESEARCH METHOD

This section describes the proposed research method for this study, mapping the research questions, as explored in Chapter 3, to the experimental design. The data collection instruments will be detailed and the subsequent data analysis techniques explained. As discussed in the previous section, the research questions addressed by the following research studies will explore the effect of meta-design inspired guidelines and participation on design-time ideation in both a controlled and real-world setting. These studies will build an understanding as to whether such a process can shift design-time ideation towards providing end users with the tools necessary to shape their technological environments during use. The remainder of the chapter is structured as follows:

4.1 Introduction
4.2 Research Questions Addressed by Experiments
4.3 Experimental Research Design

4.3.1 Independent Variables
4.3.2 Dependent Variables
4.3.3 Idea Generation Process: Proposed Guidelines
4.3.4 Experiment 1: Participatory Idea Generation
4.3.5 Experiment 2 and 3: Real World Ipl2 design exercise and Diary Keeping

4.4 Data Collection Instruments
4.1 Introduction

Meta-design extends the boundaries of system design from the creation of one original system to an ongoing co-design process between users and designers. Therefore, one key aspect of meta-design is continuously participatory design, where users and designers contribute to an ongoing design discussion around modifying the system in use. Although participatory design practices at design time have been commonly employed for many years, they primarily focus on the immediate needs of the immediate users and not the future complexities of unpredictable use time.

As explored by Steward Brand (1994) in his method of scenario-buffered design (see section 2.5.2), the more possibilities that are considered at design time, then the better suited the system becomes to future changing conditions. A design time conversation that attempts to reach out into the future and think beyond current needs sows the seeds for adaptability in the resulting system. It remains a challenge in information systems to orient design time conversations towards future use time and to understand the role of participation in such a process. As meta-design theory reinforces, future use can never be entirely anticipated, yet some work must happen at design time. This raises the key question of: what techniques can help anticipate some use time possibilities at design time?

Meta-design assumes that there is some design work (but never all design work) that must happen at design time and that work should be conducted in a participatory manner. The series of experiments explored how such design time work can be directed towards designing for an unknown future instead of only fulfilling
immediate needs. As explored in the literature review section, it is no secret that
design time work must consider the future, but the question remains as to how best to
accomplish.

In creating and testing design time guidelines oriented towards meta-design
themes and concerns, this dissertation seeks to create a framework for design time
activities that attunes the designers (and users) to future possibilities and away from
simply grounding in current needs. The experiments sought to further our
understanding of the value of user participation, as well as the effect of the
framework employed for design time idea generation and conversation.

4.2 Research Questions Addressed by Experiments

Experiment 1, on participatory idea generation, explored the effect of
participation and meta-design framework on idea generation in a laboratory setting,
through involving users and designers in design time brainstorming. Experiment 2, a
real world ipl2 design exercise, applied these findings and process to design work in a
more naturalistic setting. Experiment 3 consisted of diary-keeping by the end users
that were included in the ipl2 design exercise, and was conducted concurrently with
Experiment 2. The following table maps experiments 1, 2, and 3 to the corresponding
research question(s).
### Table 2: Research questions addressed by experiments

<table>
<thead>
<tr>
<th>Experiment 1</th>
<th>Research Questions</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>RQ1-A</strong>: What is the effect of meta-design inspired guidelines on the design ideas generated during design activities?</td>
<td>Laboratory</td>
</tr>
<tr>
<td></td>
<td><strong>RQ1-B</strong>: What is the effect of end user participation on the design ideas generated during future-focused design activities?</td>
<td></td>
</tr>
<tr>
<td>Experiment 2</td>
<td><strong>RQ2</strong>: Can meta-design inspired guidelines provide a useful framework for focusing continuous and participatory real-world design time activities on future scenarios of use?</td>
<td>Real-world</td>
</tr>
<tr>
<td>Experiment 3</td>
<td><strong>RQ3</strong>: What types of changes might end users want to make to systems during real-world use?</td>
<td>Real-world</td>
</tr>
</tbody>
</table>

### 4.3 Experimental Research Design

The research study was conducted in two phases; the first being a laboratory experiment and the second a real-world ipl2 design exercise and diary keeping exercise, both of which are detailed in the following sections. The intentions and justifications for each phase of the study are briefly described below.

The first phase explored the usefulness and validity of the meta-design inspired guidelines, in a laboratory context. This phase assessed whether the meta-design inspired guidelines helped designers generate more design ideas, or ideas oriented more towards supporting future end-user designers. This also explored whether involving end-users in these design-time conversations as user participants had an effect on the design ideas generated. Experiments 2 and 3, consisting of a real-world
ipl2 design exercise and diary keeping, explored the meta-design inspired guidelines with a real-world design group and end-user participants, again looking at the effect on the design ideas generated by the group. Additionally, the end users kept diaries of suggested changes to the system while they used it in their real-life activities to further build an understanding of the types of changes end users want to make over time. The goal of these experiments was to understand the applicability of the guidelines in a more naturalistic setting and to expand the design activities into the daily lives of the end user participants.

4.3.1 Independent Variables

There were two independent variables, user participation and idea generation process, with two levels: designers-only and designers-and-users. The designers-only conditions mimic professionally-oriented user-centered design, in which the designers drive the process and decisions. The designers-and-users conditions represent current participatory design practices in which designers and users work together to shape the system. A users-and-users condition was not explored in this study, as our current technology limits users-alone from conducting design activity and there is typically one or more skilled designer involved in design-time activities. Adding a users-and-users condition to the study would therefore have added needless complexity to the study design, without helping to further understand and improve on our current design practices.

The factors of user participation and idea generation process address research questions 1-A and 1-B exploring the effect of meta-design inspired guidelines and
user participation on design-time idea generation. These factors are of importance in that they begin to explore the effect of directly attempting to focus design-time conversation on meta-design concerns (through the factor of meta-design inspired idea generation process) and whether user participation is useful in such a process (factor of user participation).

### 4.3.2 Dependent Variables

There were four dependent measures:

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ideas</td>
<td>Design ideas identified by participants, written on sticky notes, and counted</td>
</tr>
<tr>
<td>Aggregate Time Talking</td>
<td>Measure of discussion time used by users and by designers</td>
</tr>
<tr>
<td>Idea quality</td>
<td>Measured by design experts on a simple Likert-like scale (see Data Collection Instruments)</td>
</tr>
<tr>
<td>Idea customization</td>
<td>Assessed based on ability to support customization or personalization in the hands of end users on a low, medium, or high scale.</td>
</tr>
</tbody>
</table>

### 4.3.3 Proposed Idea Generation Process: Meta-design Inspired Guidelines

The proposed idea generation process consists of a series of guidelines used in a design time exercise aimed at focusing thought away from immediate needs and towards common emergent behaviors that users engage in over time. These center around: connecting – to people with similar interests or needs, having conversations –
in real-time across space and time, *combining* – the system with other tools and systems they use, *getting up to speed quickly* – so undue time is not spent learning the system, and *tailoring* – such that the system is molded to their personal needs. Each theme is presented to the design group (of designers only or designers and users) as a concise guideline for consideration during design time brainstorming. The proposed guidelines appear in the below table (the complete data instruments can be seen in the following section – 4.6 Data Collection Instruments).

Table 4: Proposed guidelines for design exercise

<table>
<thead>
<tr>
<th>People like systems where they can:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Connect</strong> with other people with similar needs and interests, both nearby and far away.</td>
</tr>
<tr>
<td>2. <strong>Reach out</strong> and converse with other people in real-time, while they are using the system.</td>
</tr>
<tr>
<td>3. <strong>Combine</strong> it with other tools and systems they use regularly.</td>
</tr>
<tr>
<td>4. <strong>Begin using it quickly</strong>, without a lot of help or instruction.</td>
</tr>
<tr>
<td>5. <strong>Adapt it</strong> to their personalized needs.</td>
</tr>
</tbody>
</table>

Any number of ideas could have been chosen for representation in the guidelines as a starting point. The concepts chosen are clear and understandable, such that both experienced designers and users could relate to and utilize them. They come from key literature informing the meta-design perspective and therefore serve as a strong starting point for this approach. The overall process itself is inspired by
Stewart Brand’s scenario-buffered design (1994), in which designers and users collaborate in a future-focused brainstorming exercise to form an adaptable strategy for the design leaving it more resilient to future conditions (see section 2.5.2). Brand’s process involves multiple stakeholders over multiple sessions in a compressed timeframe. The goal of the guidelines explored in this series of experiments is to create a light-weight version of Brand’s “scenario-buffered” process, by extracting the key functions of such a process: to focus designers and/or end users on future possibilities and to brainstorm features supporting such divergent futures (see section 2.5.2). The rationale behind the inclusion of each guideline is described below:

Guideline 1: **Connect** with other people with similar needs and interests, both nearby and far away.

John Thackara’s (2005) series of design frameworks for complex worlds emphasizes the increasing importance of systems that allow people to connect and communicate both locally and across the boundaries of time and space. Technology systems provide a valuable means of connecting, building, and extending the communities of practice that support users in many aspects of their daily lives. This guideline intends to encourage these possibilities by focusing designers on how users can use the system to connect to similar people, and how they might attempt to extend the system in this fashion. The massive popularity of social networking tools (eg. Myspace, Facebook) emphasizes how powerful the need to connect with other people is and how users seek to make such connections across nearly every dimension of
their lives’ (work, education, health, dating, etc.) even if systems are not intentionally
designed for these purposes.

Guideline 2: **Reach out** and converse with other people in real-time, while they are
using the system.

Research prior to meta-design has explored modifiable systems that allow for
reflective use-time conversations to occur, between designers and users (e.g. Fischer,
Lemke, Mastaglio, & Morch, 1990). This guideline seeks to emphasize how users can
have live experiences and conversation with other people within, or around, the
system. This may be with other users, with designers, or with knowledgeable users
acting as designers. And, more generally, people use their social networks to
accomplish their goals and answer questions, even if it means ignoring “formal”
channels (e.g. Suchman, 1987). Research in recent years has explored the emergent
use of chat and microblogging tools, such as Twitter, to facilitate backchannel
conversations during conference presentations (e.g. McCarthy, Boyd, Factors, and
Computing Systems (CHI 2005, & 2005), as well as in many other domains, such as
collaborative learning.

Guideline 3: **Combine** it with other tools and systems they use regularly.

The new (or redesigned) system may be only one of several tools and systems
they use on a daily basis or even at the same time. As Bødker emphasized, technology
configurations will increasingly involve multiple people and multiple systems
(Bødker, 2006). Designing for these complex environments is a challenge facing HCI
today and many theoretical frameworks (e.g. distributed cognition (Hutchins, 1995))
describe the intensely combinatory and situated nature of real life use. While designers can never anticipate exactly how their system might be used, they can view it as only one piece of a larger, evolving puzzle and not assume it to be a discrete system with 100% of the user’s focus. And as Thackara points out, this focus, to the surrounding edge and combinatory effects, may spark new ideas (Thackara, 2005). This behavior is currently evident in the increasing popularity of web application “mashups”, where users can combine disparate data sources and programming interfaces to create novel tools; this trend is reflected in the emerging literature studying this phenomenon (e.g. Hartmann, Doorley, & Klemmer, 2006).

Guideline 4: **Begin using it quickly**, without a lot of help or instruction.

Alexander’s unselfconscious culture of design (1964) requires systems users can understand relatively quickly and then contribute to confidently. This breaks down mental and physical barriers that prevent users from understanding the space or system well enough to have opinions and take actions to modify it. The goal of this design exercise is not to overload users with a multitude of features; this guideline is oriented towards envisioning ways in which novice users could begin using systems quickly and confidently, potentially becoming empowered to act as designers. There are many open questions around what motivates users to contribute to design activities; breaking down obvious barriers to use can encourage users acting as designers. The continuing attention paid to system *usability* in both academia and industry over the past few decades underlies the users’ need for effective, usable systems.
Guideline 5: **Adapt** it to their personalized needs.

Henderson and Kyng’s (Henderson & Kyng, 1991) early writings on designing in use identified tailorability as essential to systems supporting users acting as designers. There are many ways in which systems can be tailorable or adaptable: the system may tailor itself to the particular individual’s needs automatically or through the user’s tailoring actions. Successful systems, at this stage of technological development and users expectations, will likely all require some level of personalization and tailoring. It is the intent of this guideline to bring these needs to the forefront of design discussions and decisions. Considering tailorable aspects can put the necessary tools into the hands of the users if (and when) the need for future modifications arise. A recent example of the necessity of supporting such behavior is exemplified by the Apple iPhone. Though these devices are officially designed to be exactly the same, users can extensively personalize and adapt the device to their needs; the popularity of the AppStore, which shares and sells tools designed by and for users, emphasizes the natural tendency towards continuing design in use.

The total number of guidelines was intended to remain small, so that the design exercise would be relatively quick and easy to conduct. The guidelines were intended to be presented so that participants could help imagine future uses of the system, from the perspective of the users. To facilitate this use, the guidelines were presented not as “rules” but rather as best practice oriented around what people naturally do with systems (whether they are intentionally designed that way or not).
4.3.4 Experiment 1: Idea Generation Process – Meta-Design Inspired Guidelines

This initial laboratory experiment sought to explore how design-time thinking can be oriented towards future possibilities for use, by manipulating the factors of participation and idea generation process, each factor with two levels. Participants (working in groups of either designers-only or both designers-and-users) were given either a) the proposed meta-design inspired guidelines or b) no instruction, then asked to identify key future issues influencing use and to generate ideas for the future system. The following details expand upon this study design and the measurements gathered.

2x2 Factorial Design

An experimental between-groups design was used to explore the key factors of meta-design inspired idea generation process and end user participation addressed by the research questions RQ1-A and RQ1-B. The below table illustrates the between subjects 2x2 factorial design.
There are several additional factors that could have been added to expand the factorial design, namely an existing design process as another idea generation process factor or another participation factor of users only. These were intentionally omitted both for the pragmatic reason of limiting the study size to an appropriate scope for this work and for concerns around the potential value added.

With respect to adding an additional, existing HCI design process (such as claims analysis or heuristic evaluation), this study serves as a starting point for evaluating whether or not such an approach makes a difference to design-time activities, by pitting the technique against a control group.
Table 6: Common HCI design techniques

<table>
<thead>
<tr>
<th>Design Method</th>
<th>Purpose of Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claims Analysis</td>
<td>Examine potential positive or negative consequences of a particular design feature</td>
</tr>
<tr>
<td></td>
<td>(Carroll &amp; Rosson, 1992)</td>
</tr>
<tr>
<td>Personas</td>
<td>Rich descriptions of typical users that designers can focus on and design for (Cooper, 1999)</td>
</tr>
<tr>
<td>Scenarios</td>
<td>Envision realistic and specific scenarios of use (positive or negative) through “informal narrative description” (Carroll, 2000)</td>
</tr>
<tr>
<td>Use Cases</td>
<td>Describe detailed series of actions necessary for each task focusing on the necessary actions from the user (“actor”) and the system’s response (Jacobson, Christerson, Jonsson, &amp; Overgaard, 1992)</td>
</tr>
<tr>
<td>Essential Use Cases</td>
<td>Structured narratives that represent more general case than scenarios, without assumptions about technology as in typical use case (Constantine &amp; Lockwood, 1999)</td>
</tr>
<tr>
<td>Participatory Design</td>
<td>Co-creation of design artifacts through a variety of methods (workshops, co-designing prototypes, etc.) (Ehn &amp; Kyng, 1987)</td>
</tr>
<tr>
<td>Heuristic Evaluation</td>
<td>Designers evaluate interfaces against a series of guidelines based on best-practices and knowledge of typical users (Nielsen &amp; Molich, 1990)</td>
</tr>
<tr>
<td>Cognitive Walkthrough</td>
<td>Designers simulate a user’s problem solving process in each step of a given task and potential complications a user might encounter (Nielsen &amp; Mack, 1994)</td>
</tr>
</tbody>
</table>

Although there are no well-used processes within HCI techniques with the exact same goals as the proposed meta-design based guidelines, the tables above and below assess some existing techniques and the similarities and differences. The HCI methodologies included are typically included in both human-computer interaction practices as well as educational curriculum (e.g. Rogers, et al., 2011). The following table explores the similarities and differences between these existing techniques and meta-design approaches, such as SER and the proposed meta-design inspired guidelines.
Table 7: Similarities and differences between HCI and meta-design techniques

<table>
<thead>
<tr>
<th>Methods</th>
<th>Envision future needs</th>
<th>Support unanticipated uses</th>
<th>Support intended uses</th>
<th>Support current users</th>
<th>Co-design activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCD</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Claims analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personas</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenarios</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use cases</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participatory design</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Heuristic evaluation</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cognitive walkthrough</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Meta-Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SER model</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Scenario-buffered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>design</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meta-design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>inspired guidelines</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

As the above table details, many of the existing HCI techniques bear some similarities to the meta-design inspired guidelines, most notably around describing and predicting future use and future end users. As the goals differ, no one technique is appropriate for inclusion in this initial study. Rather, future studies can compare the differences between existing techniques and the proposed meta-design inspired guidelines.

Additionally, a “users only” level seems like a logical addition to the participation factor but would be rarely (if ever) occurring in the real life design situations that this work is oriented towards and therefore adds little value to the study and more difficulty in acquiring participants.
Participants

Participants were Drexel University undergraduates and graduate students recruited as either users, as defined by little or no experience or education in system design or development, or designers, as defined by having taken at least one design course. Design courses were considered to be any courses in human-computer interaction and/or interaction design taken at Drexel University’s iSchool (e.g. INFO 110, 310, 608, 610, 611). The chosen courses covered human-computer interaction theory as well as methodology and gave students hands-on experience in applying such techniques in design projects. “Users” were recruited from non-technical schools within the university, such as in the social sciences; “designers” were recruited from technical and design oriented schools, such as information science and technology. Participants were randomly assigned to work in groups of two, consisting of either two users or one user and one designer. An a priori power analysis indicated that the total number of participants necessary to reach statistical significance would be 32 participants (8 in each treatment condition). The following tables summarize the demographics and self-proscribed design and development experience of the participants used in the experiment.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Freq.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>23</td>
<td>72%</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
<td>28%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-23</td>
<td>17</td>
<td>53%</td>
</tr>
<tr>
<td>24-29</td>
<td>8</td>
<td>25%</td>
</tr>
<tr>
<td>30-45</td>
<td>7</td>
<td>22%</td>
</tr>
<tr>
<td>Program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>15</td>
<td>47%</td>
</tr>
<tr>
<td>Graduate</td>
<td>17</td>
<td>53%</td>
</tr>
<tr>
<td>Major</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Systems</td>
<td>12</td>
<td>38%</td>
</tr>
<tr>
<td>Library and Information Science</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>Information Technology</td>
<td>4</td>
<td>12%</td>
</tr>
<tr>
<td>Information Studies</td>
<td>4</td>
<td>12%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Software Engineering</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Digital media</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Accounting</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>1</td>
<td>3%</td>
</tr>
</tbody>
</table>

Participants were asked to rate their systems development and design skills on a five-point scale (Table 9).

<table>
<thead>
<tr>
<th></th>
<th>Designers</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Experience</td>
<td>2.29 0.74</td>
<td>1.6 0.74</td>
</tr>
<tr>
<td>Design Experience</td>
<td>2.5 1.14</td>
<td>1.5 0.75</td>
</tr>
<tr>
<td>Number of design courses taken</td>
<td>1.58 0.82</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Design Task**

Participants were asked to generate ideas around the design of a textbook trading website. This design task has been chosen as it covers a domain in which users are likely familiar (i.e. buying, selling, and using textbooks), but represents a
specific design problem that they do not have hands-on experience with. This allowed for relatively easy idea generation, without being limited by previous experiences or implementation details.

Control Condition

In the control condition, participants were first asked to identify the key factors affecting the system use and then brainstorm ideas around possible future users without explicit instruction or framework for thought. The control condition was conducted with both the designers-only and designers-and-users levels.

Meta-Design Inspired Guidelines Condition

In the guidelines condition, participants followed the same process as the control condition but were be given a framework for thinking around future possibilities, based on the goal of meta-design systems to facilitate end-user customization. The guidelines condition was conducted with both the designers-only and designers-and-users levels.

Procedure

Participants working in groups of two, either designers-only or designers-and-users, were prepped with the design problem and guidelines (in guidelines conditions only). The “design exercise” in the data collection instruments section provides an example of the instructions that were provided. The process followed for the laboratory study was as follows:
1. Participants were asked to fill out a brief demographics form.

2. Participants were read a brief introduction stating the general purpose of the study and given pens and sticky notes.

3. In Step 1 (identification of important factors), participants were asked to identify the important factors influencing system use. This step served as an “ice breaker” exercise, to facilitate discussion between participants, and allow them to begin to explore the domain of textbook trading.

4. In Step 2 (idea generation process), participants were asked to brainstorm ideas and write unique ideas on sticky notes.

5. In the guidelines conditions, participants were asked to write the guideline relating to the idea on the sticky note.

Data Analysis

As detailed above, the following dependent variables were measured and collected by the researcher: number of ideas, aggregate time talking, idea quality, and idea customization. These four dependent variables were used to explore RQ1-A and RQ1-B:

RQ1-A: What is the effect of meta-design inspired guidelines on the design ideas generated during design activities?

RQ1-B: What is the effect of end user participation on the design ideas generated during future-focused design activities?
Four dependent variables were analyzed to answer these questions and build an understanding of the main effects of the meta-design inspired guidelines and end user participation in design activities. The primary variables that were analyzed for statistical significance during this laboratory study and the rationale for their inclusion are as follows:

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Description</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ideas</td>
<td>Design ideas identified by participants, written on sticky notes, and counted</td>
<td>An analysis of the mean number of ideas generated across conditions will indicate whether the main effect of meta-design inspired guidelines and/or participation yields significant differences in idea generation.</td>
</tr>
<tr>
<td>Aggregate Time Talking</td>
<td>Measure of discussion time used by users and by designers</td>
<td>An analysis of discussion time used by users vs. designers will indicate whether the guidelines or control group yield significant differences in end user contributions to design discussion.</td>
</tr>
<tr>
<td>Idea quality</td>
<td>Measured by design experts on a simple Likert scale (see Data Collection Instruments)</td>
<td>These quality measures will be used to explore whether the main effect of meta-design inspired guidelines and/or participation yields significant differences in idea quality.</td>
</tr>
<tr>
<td>Idea customization</td>
<td>Assessed based on ability to support customization or personalization in the hands of end users on a low, medium, or high scale.</td>
<td>This measure will be used to explore whether the main effect of meta-design inspired guidelines and/or participation yields significant differences in the number of ideas that are oriented towards future customization in the hands of end users.</td>
</tr>
</tbody>
</table>
4.3.5 Experiment 2 and 3: ipl2 Design Exercise and Diary Keeping

One key aspect of meta-design is that design evolves in a continuous and participatory way throughout the lifetime of the system. This second phase of the experiment sought to build on findings from the previous laboratory phase, by employing the developed guidelines in real life design activities across time. Iterative participatory design is a common design activity today, although few of our current systems allow for continuous iteration with input from both designers and users, and participatory design typically focuses on the immediate needs only. Experiment 2 and 3 address the following research questions exploring how the meta-design inspired guidelines might apply to real-world design and the type of changes end users might want to make to systems during use:

*RQ2: Can meta-design inspired guidelines provide a useful framework for focusing continuous and participatory real-world design time activities on future scenarios of use?*

*RQ3: What types of changes might end users want to make to systems during real-world use?*

In the interest of exploring participatory design as envisioned by meta-design, the same process from the earlier experiment stage was employed in idea generation activities focused on a redesign of the Internet Public Library (ipl2; http://www.ipl.org). The Internet Public Library (currently known as ipl2) is an online-based public service organization and a learning and teaching environment originally developed by the University of Michigan’s School of Information and
currently hosted by Drexel University’s iSchool. The ipl2 consists of a publicly accessible website, with several large content collections and sections targeted towards teens and children, and a question and answer service, where users can email questions to be answered by volunteer librarians (Maceli, Wiedenbeck, & Abels, 2011).

In experiments 2 and 3, end user participants kept diaries to record desired changes to the ipl2, as they arose during their everyday work on the system. During this phase, a group consisting of these end users and ipl2 designers (as described further below), met to conduct the design exercise using the meta-design inspired guidelines. This group met twice, in order to allow time to reflect and iterate upon the ideas generated.

The ipl2 design exercise and diary keeping began to explore how such a process might work in real-world continuously participatory design practices and inform future research directions. This begins to address continuous participatory design within a pragmatic approach, where revisiting of ideas is permitted, but design conversation is not perpetually taking place. This mirrors the real-life development of systems where incremental tweaks occur from time to time, contributing towards the lifetime of change that the system will undergo. Additionally, the diary method was used to capture desired modifications that arise in use, motivated by the users’ real world experiences with the system. These desired modifications were explored further during the design exercise with ipl2 designers. Due to the availability of the design team and end users the design exercise was conducted two times over a period
of two weeks. Although a longer time-frame was desirable, in the two sessions a fair amount of overlap was observed with the same ideas being explored across both sessions. This begins to indicate that useful design sessions should be spaced further apart in time, which was outside the scope of the study design. Although this experiment does not represent a true longitudinal study (which is a goal of future work), it begins to extend potential meta-design methods continuously across space and time.

Participants

Participants for the diary keeping study were two LIS graduate students enrolled in a course utilizing the ipl2’s website. These participants had vested interested in the design of the system, but little to no formal system building experience. A group consisting of these two end users and three ipl2 designers was formed to complete the iterative design exercise.

<table>
<thead>
<tr>
<th>Role</th>
<th>Gender</th>
<th>Age</th>
<th>Development Experience</th>
<th>Design Experience</th>
<th>Time using or working on ipl2</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1  Designer</td>
<td>F</td>
<td>32</td>
<td>High</td>
<td>High</td>
<td>2 years</td>
</tr>
<tr>
<td>P2  Designer</td>
<td>F</td>
<td>28</td>
<td>Low</td>
<td>Medium</td>
<td>1 year, 9 months</td>
</tr>
<tr>
<td>P3  Designer/ Developer</td>
<td>M</td>
<td>29</td>
<td>High</td>
<td>Medium</td>
<td>6 months</td>
</tr>
<tr>
<td>P4  End User</td>
<td>F</td>
<td>25</td>
<td>Low</td>
<td>Low</td>
<td>1 year</td>
</tr>
<tr>
<td>P5  End User</td>
<td>M</td>
<td>21</td>
<td>Medium</td>
<td>High</td>
<td>6-9 months</td>
</tr>
</tbody>
</table>
Procedure

Participants for diary keeping were recruited from LIS courses and given the paper diary template (see Data Collection Instruments section below). Additionally, they were emailed a digital copy of the diary template, which both participants chose to use. Participants were given instructions to complete a diary entry every time they encountered a problem or potential improvement of the ipl2 while they were using the system in the context of their daily lives:

*During the course of your day, when you are using the ipl2’s website, please write down any problems you encounter or possible improvements that could be made. Also, if you have any ideas or solutions to these issues, please write these down as well.*

The use of the system could be for coursework or any other information seeking goal. The participants were instructed to add one entry in the diary, or multiple entries, depending on the number of problems encountered and to time-stamp those entries. Participants were asked to keep diaries over the course of two weeks, during which they also participated in the two ipl2 design exercise sessions.

The two diary-keeping participants completed the design exercise from experiment 1, while working with two ipl2 designers. In an exercise that was repeated once (for a total of two data collection sessions) over a period of several weeks, participants were prepped with the design problem (a redesign of the ipl2 website) and the meta-design inspired guidelines. Using this framework for thinking around future possibilities, they were asked to identify the key factors affecting the
system use and then brainstorm ideas around possible future scenarios of use. They were asked to identify the particular guideline that aided with the idea creation, if relevant. As the focus of this experiment was on idea generation and participation, and not on implementation, this exercise will consist of brainstorming, periods for reflection, and idea generation without any coding or programming work.

Only the designer-and-users and guidelines condition (MD2) was conducted in the naturalistic study. There is only a small group of real IPL designers making it impossible to create the equivalent experimental groups used in the previous portion of the study. Therefore, this portion of the study focused on exploring how participation and the guidelines work with real life design problems.

**Data Analysis**

For the diary-keeping portion of the study, the diaries were collected from the two end user participants at the end of the two week period. This yielded a set of data describing their activities on ipl2, the problems or improvements identified, and their design ideas. The problems and ideas, as textual data, were analyzed qualitatively, using inductive coding to determine any themes in the type of suggestions made. For the ipl2 design exercise with the designers and users, similar dependent variables as the earlier experiment were collected (number of ideas, number of words spoken in design discussion, and idea customization.). Additionally, data was gathered as to what guidelines were most-used.

The results of this portion of the study serve as a proof of concept that begins to build understanding around whether such a process might help within existing
design practices to focus design-time opportunities on future scenarios of use. Observing this process will help illustrate how well such a process might work in real design activities, in helping designers and users work together more efficiently, uncovering more potential scenarios for use, or more creative or innovative ideas. The dependent variables collected help understand the contribution of users vs. designers in idea generation and design conversation, as well as the quality and number of ideas generated. Additionally, an understanding of what guidelines are most useful to real life design settings help shape the future direction of this framework and suggest future iterative changes.

4.4 Data Collection Instruments

Demographics Questionnaire

Participants were asked to fill out the following demographics questionnaire at the beginning of the session. This data was used to identify participants as either with design experience (“designer” role) or without design experience (“user” role). The demographics questionnaire focused on school, program, and year to determine whether participants came from a design-oriented program. It then explored their systems development and systems design experience, asking the participant to rate their expertise, as well as identify any design-oriented courses they had taken. This data was used to summarize participant attributes for descriptive purposes, as well as to assign participants to the appropriate treatment group.
Table 12: Demographics questionnaire filled out by study participants

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender:</td>
<td>Male / Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major:</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**System Development/Design Experience**

What systems development experience do you have (through school, co-op, internship, or other work)?

How much expertise do you have with systems development?

<table>
<thead>
<tr>
<th>Low Expertise</th>
<th>High Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

What systems design experience do you have (through school, co-op, internship, or other work)?

How much expertise do you have with systems design?

<table>
<thead>
<tr>
<th>Low Expertise</th>
<th>High Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Coursework**

What coursework have you taken that is related to systems development or design (at Drexel or other academic institutions)?

*Experiment 1: Design Exercise*
The following data instruments were used during the two-step design exercise in experiment 1, the laboratory experiment exploring the effects of meta-design inspired guidelines and end user participants on design ideas generated.

Table 13: Experiment 1 design exercise materials

<table>
<thead>
<tr>
<th>Design Exercise: Designing a Textbook Trading Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Introduction read by researcher]</td>
</tr>
<tr>
<td>I am going to ask you to pretend that you are entrepreneurs creating a new website for college students to use to exchange textbooks. Today you will be brainstorming ideas for the design of your new textbook trading website. I will be asking you to think about possible uses of your system over the next five years. I’d like you to focus on the features people might want in the future, not just today.</td>
</tr>
<tr>
<td>This exercise should take less than an hour. You will be working with one other person and I will be observing. I am interested in the kinds of ideas you come up with, so as far as this exercise is concerned there are no bad ideas, I just want to see everything and anything that comes to your mind.</td>
</tr>
<tr>
<td>To begin with, do you have a general idea of what a textbook trading website would be? There is no one “right” answer here, I just want to make sure you have a general idea before we begin working.</td>
</tr>
<tr>
<td>[let participants say what they think it is]</td>
</tr>
<tr>
<td>Ok, that’s a great place to start.</td>
</tr>
<tr>
<td>We are going to do two steps today. The first will ask you to think about issues that might affect your textbook trading website.</td>
</tr>
<tr>
<td>The second step will ask you to come up with some ideas for what features your textbook trading website might have. [optional] You will be looking at some guidelines that may help you think of ideas.</td>
</tr>
<tr>
<td>Do you have any questions before beginning?</td>
</tr>
</tbody>
</table>

Step 1 (of 2):
What are the important issues that might influence how your system is used over the next 5 years?

One example might be:

*The price of textbooks keeps going up and students want cheaper options*

Write down the important issues that could affect your textbook trading website:

**Step 2: (one of below options)**

---

**--Option 1--**

What are some possible ways people could use your textbook trading website over the next 5 years?

One example might be:

*Look at the table of contents of a textbook they need for class*

Below is a series of guidelines that may help you think up ideas.

Write one idea per sticky note and which guideline it relates to, if any.

--------

People like systems where they can:

1. **Connect** with other people with similar needs and interests, both nearby and far away.

2. **Reach out** and talk with other people, while they are using it.

---

**--Option 2/Control--**

What are some possible ways people could use your textbook trading website over the next 5 years?

One example might be:

*Look at the table of contents of a textbook they need for class*

Write one idea per sticky note.
3. **Combine** it with other technologies they use regularly.

4. **Begin using it quickly**, without a lot of help or instruction.

5. **Adapt** it to their personalized needs.

---

**Experiment 2: Diary Template**

The following diary keeping template was given to end user participants to complete over the course of the study:

**IPL2 Diary Template**

*Instructions:*

*During the course of your day, when you are using the ipl2’s website, please write down any problems you encounter or possible improvements that could be made. Also, if you have any ideas or solutions to these issues, please write these down as well.*

*Questions? Email Monica Maceli at mgm36@drexel.edu*

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>What are you doing on the ipl2 right now?</th>
<th>What is the problem or possible improvement?</th>
<th>Do you have any ideas or solutions to this problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
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<tr>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
Experiment 2: Design Exercise

The same design exercise as above was conducted with the ipl2 redesign as the design problem and only using first option for Step 2 (guidelines condition).

Likert Scale: Idea Quality

The following form was given to design experts to assess the quality of the design ideas generated by each of the groups in experiment 1 (16 groups in total).

Evaluation Form for Participant’s Design Ideas

During a design exercise, groups of participants brainstormed ideas for the design of a website for students to use to trade textbooks. Please use this form to rate the quality of the design solution that was generated by each group of participants. Each group of ideas represents one group’s proposed solution for a ‘textbook trading website’.

Group Number

Please rate each of the quality elements based on the definitions below:

- **Level of Detail** – How low-level and non-vague are the elements of the design?
- **Completeness** – How complete is the design? Does the design contain all the necessary parts that it will need to work?
- **Flexibility** – How much of the design can users personalize, contribute to, or otherwise modify?
- **Originality** – How novel is the design? Does the design seem new or surprising in any way?
- **Overall Quality** – Overall how good of a solution is the design?
<table>
<thead>
<tr>
<th></th>
<th>Not at all Detailed</th>
<th>Very Detailed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level of Detail</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>Completeness</strong></td>
<td>Not at all Complete</td>
<td>Very Complete</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>Not at all Flexible</td>
<td>Very Flexible</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>Originality</strong></td>
<td>Not at all Original</td>
<td>Very Original</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>Overall Quality</strong></td>
<td>Very poor Quality</td>
<td>Excellent Quality</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

Other Comments:

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

________________________________________________________
_________________________________________________
This chapter presents the data analysis methods and results arranged by the three experiments (Experiments 1, 2 and 3), and by the relevant research question(s) within each experiment. The results presented in this chapter will be explored in greater depth and interpreted in the following discussion chapter. The remainder of this chapter is organized in the following manner:

5.1 Introduction

5.2 Data Collection and Overview of Sample Population

5.3 Summary of Results

5.4 Experiment 1 Results

5.4.1 Research Question 1-A: Effect of meta-design inspired guidelines

5.4.2 Research Question 1-B: Effect of end user participation

5.5 Experiments 2/3 Results

5.5.1 Research Question 2: Applicability to real-world design

5.5.2 Research Question 3: Desired end user modifications

5.6 Conclusion and Main Findings
5.1 Introduction

The guidelines (Table 4) are based primarily on literature and recent technological trends; the intention of the series of three experiments was to validate the guidelines with real world designers and users. In validating the guidelines in variety of contexts, this research study explores a framework for design time activities that attunes the designers (and end users) to future possibilities, and away from the immediate needs of the immediate users. The experiments seek to further our understanding of the value of user participation, as well as the effect of the framework employed for design time idea generation and conversation.

In pursuit of these goals, a laboratory study (experiment 1) was first conducted to assess the usefulness and understandability of the guidelines to both designers and end users. Meta-design is inherently embedded in real world, emergent use. In order to better understand their potential application to real world design activities, a subsequent ipl2 design exercise (experiment 2) was undertaken in which the guidelines were used with an existing website’s design team working with end users; additionally, these end users participated in a diary keeping study (experiment 3) in which they suggested changes to the system during real-world use.

5.1.1 Laboratory Study

In a laboratory setting, 32 participants were used in a two-factor between subjects design, exploring the main effects of participation (including end users or designers only) and the guidelines (working with or without guidelines). Individual participants, all either graduate or undergraduate students at Drexel University, were
asked to rate their systems development and design skills on a five-point scale. Participants categorized as “users” had not taken any courses in design or had any formal training in design methodology. Participants categorized as “designers” were enrolled in information technology programs and had completed at least one design course.

Participants, working in pairs of either two designers or one designer and one user, were asked to conduct ideation using the meta-design inspired guidelines. Participants were asked to design a “textbook trading website” for college students; they were first asked to brainstorm and identify key issues and trends that may affect their website in the future (e.g. – “The price of textbooks keeps going up and students want cheaper options”). Participants were then given the guidelines to review individually, and asked to work together to write down any design ideas for the website that were sparked by the various guidelines, as well as any ideas they felt fell outside them.

5.1.2 Ipl2 Design Exercise and Diary Keeping – The ipl2

In order to explore the use of the guidelines in a real world context a ipl2 design exercise was then undertaken involving the ipl2. The ipl2 is a digital public library, hosted by the iSchool at Drexel University, and continuously developed by faculty and students at a consortium of colleges and universities with information science programs (see Figure 2 below). The participants in the ipl2 design exercise consisted of two ipl2 designers, one ipl2 designer/developer, and two end users who were librarians in training. All participants had worked on the ipl2 for a minimum of
6 months. The ipl2 design exercise participants met in two iterative sessions to conduct ideation using the meta-design inspired guidelines, in a similar design process as in the laboratory study.

The website designer/developers and end users met in two iterative sessions to conduct ideation using the meta-design inspired guidelines, in a similar design process as in the laboratory study. Participants were first asked to brainstorm and identify key issues and trends that may affect the ipl2 in the future (e.g. – “Expanded internet accessibility in the US and beyond”). Participants were asked to focus their thoughts on changes and issues that would arise in the next 5 to 10 years. Participants were then given the guidelines to review and then asked to work as a group to write down any design ideas for the ipl2 that were inspired by the various guidelines.

The same process was followed for the second design session, with the final addition of creating a list of the top ideas they would like to implement immediately.
The intention of multiple sessions was to both spread design activities across time, as well as give participants time to reflect on the design ideas in between sessions. All design activities were video recorded and later transcribed by the researcher.

Additionally, the end users were given diaries in which to record desired changes that came to mind while they worked on the ipl2 in the context of their daily lives, between the two design sessions. These diaries were turned in to the researcher as well as brought in to the second design session to aid in design ideation.

5.2 Data Collection and Overview of Sample Population

For experiment 1, thirty-two participants were sampled between August 2010 and February 2011. Individual participants were first identified as with or without design experience, then randomly assigned to one of the treatment conditions.

For experiment 2, the participants in the ipl2 design exercise consisted of three designer/developers of the ipl2 and two end users, librarians in training. Participants were asked to rate their design and development experience, as well as the time spent working on or using the ipl2. The ipl2 design exercise participants met in two design sessions in April 2011, with the end users keeping diaries in between design sessions.

5.3 Summary of Results

The following table summarizes the results from the series of three experiments as related to the relevant research questions. These results are followed by a more
detailed list of additional findings; all the results will be explored in greater depth in the remainder of this chapter.

Table 14: Summarization of results

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Data Analysis Method(s)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1: Laboratory Study</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ1-A – effect of guidelines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Ideas</td>
<td>ANOVA</td>
<td>No statistically significant difference</td>
</tr>
<tr>
<td>Aggregate Time Talking</td>
<td>ANOVA</td>
<td>No statistically significant difference</td>
</tr>
<tr>
<td>Idea Quality</td>
<td>ANOVA</td>
<td>No statistically significant difference</td>
</tr>
<tr>
<td>Idea Customization</td>
<td>Inductive qualitative analysis</td>
<td>Qualitative findings explored in Results section.</td>
</tr>
<tr>
<td></td>
<td>Pearson’s chi-square</td>
<td>Significant difference in groups working with/without guidelines. $\chi^2(17, N=270) = 55.02, p &lt; .001$.</td>
</tr>
<tr>
<td><strong>Experiment 2/3: Ipl2 design exercise/Diary-King Study</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ2 – real-world applicability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Analysis Method(s)</td>
<td>Results</td>
<td></td>
</tr>
<tr>
<td>Inductive qualitative analysis</td>
<td>Qualitative findings explored in Results section.</td>
<td></td>
</tr>
<tr>
<td>RQ3 – end-user modifications in use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inductive qualitative analysis</td>
<td>Qualitative findings explored in Results section.</td>
<td></td>
</tr>
</tbody>
</table>

As summarized in the above table, in *experiment 1* neither factor of participation or use of meta-design inspired guidelines showed a significant difference in the number of ideas generated, overall quality of the ideas, or time spent talking. The qualitative analysis of ideas oriented towards customization, revealed significantly more ideas oriented around future modifications in the treatment groups using the
meta-design inspired guidelines. The following observations were made in experiment 1:

- 32 participants, working in pairs, were divided equally amongst the four treatment conditions, exploring the main effects of use of meta-design inspired guidelines and end user participation.
- The number of ideas, overall quality of ideas, and aggregate time talking was not significantly different between treatment groups, in a univariate analysis of variance (p > .05).
- “Adapt” and “connect” were the most-referenced guidelines, with the other three guidelines referenced roughly equally.
- A qualitative analysis of idea content revealed 43% of ideas facilitating end user customization in the groups working with guidelines, versus 30% of ideas in groups working without guidelines.

In experiment 2, the ipl2 ipl2 design exercise, 25 design ideas were generated by the group in the first session and 21 design ideas were generated in the second session. Each guideline was referenced by participants between 3 to 7 times in each session. The following key findings were observed:

- Designers and users were able to use the guidelines equally well and contribute roughly equally to design conversations
- More experienced designers generated more ideas
• Prominent themes emerging from the ideas generated were (in order of frequency): features to facilitate asking questions, expanding to new apps and platforms, improving finding and searching, allowing for user-contributed content and personalization features.

• Most ideas were low customization (47%), medium represented 41% of ideas, and high customization ideas were 10%.

In experiment 3, the diary keeping by end users, participants generated approximately 20 ideas for improving the system. The majority of ideas related to functional changes to the system that would improve efficiency of use and usability in the short term.

In summation, these results indicate that the guidelines helped participants shift their design ideas towards ones facilitating customization in the hands of future end users; this finding was true for both groups of designers only and groups including end users and was observed in the laboratory and ipl2 design exercise setting. The end users included in all phases of the study were able to confidently contribute to design discussions, using the guidelines to frame these conversations. These are promising findings, indicating that the guidelines themselves were written in such a way as to be accessible to those with varying levels of design experience and that they triggered brainstorming around future end-user customization. They were used in design activities over time, moving towards the idea of continuous design, and they facilitated participatory co-design, in providing a framework for designers and end
users to use to structure design discussion. These results, from each of the experiments, will be discussed in greater detail in the following sections.

5.4 Experiment 1 Results: Laboratory Study

As detailed earlier, experiment 1 sought to explore the effects of meta-design inspired guidelines and end user participation on design-time idea generation. In this laboratory study, the dependent variables collected included the number of ideas generated, the time spent talking by each participant, and the quality of the ideas generated, as assessed by design experts after the session on a 7-point scale. In addition to these variables, a qualitative analysis was undertaken in order to build an understanding of how the ideas generated by the treatment groups differed and how these themes relate to meta-design concepts. The following sections detail the findings as related to research questions 1-A and 1-B, exploring the effect of the meta-design inspired guidelines and end user participation.

5.4.1 Research Questions 1-A & 1-B: Effect of meta-design inspired guidelines and effect of end user participation

The following series of tables summarizes the findings for the dependent variables collected across all four treatment groups as related to research questions 1-A and 1-B, exploring the effect of use of the meta-design inspired guidelines and participation on design idea generation. The following table reports the descriptive statistics for the dependent variables that were analyzed quantitatively:
Table 15: RQ1-A & RQ1-B - descriptive statistics

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Ideas Generated</th>
<th>Time Talking (in seconds)</th>
<th>Words Written</th>
<th>Overall Quality Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>STD</td>
<td>Mean</td>
<td>STD</td>
</tr>
<tr>
<td>User/Designer w/o Guidelines</td>
<td>16.00</td>
<td>8.71</td>
<td>483.50</td>
<td>365.39</td>
</tr>
<tr>
<td>User/Designer w/ Guidelines</td>
<td>13.25</td>
<td>5.96</td>
<td>487.75</td>
<td>243.86</td>
</tr>
<tr>
<td>Designer/Designer w/o Guidelines</td>
<td>16.75</td>
<td>4.34</td>
<td>453.25</td>
<td>227.46</td>
</tr>
<tr>
<td>Designer/Designer w/ Guidelines</td>
<td>15.75</td>
<td>5.73</td>
<td>609.00</td>
<td>247.60</td>
</tr>
</tbody>
</table>

None of the observed values were found to be statistically significantly different in a univariate analysis of variance (p > .05). The following table summarizes the statistical findings for the dependent variables collected:

Table 16: RQ1-A & RQ1-B - summary of statistical findings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dependent Variable</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guidelines</td>
<td>Number of Ideas</td>
<td>Non-significant. F(1, 12) = 0.34, p = 0.56</td>
</tr>
<tr>
<td></td>
<td>Time Talking</td>
<td>Non-significant. F(1, 12) = 0.33, p = 0.57</td>
</tr>
<tr>
<td></td>
<td>Idea Quality</td>
<td>Non-significant. F(1, 12) = 2.12, p = 0.17</td>
</tr>
<tr>
<td></td>
<td>Idea Customization</td>
<td>Qualitative differences explored in Results section.</td>
</tr>
<tr>
<td>Participation</td>
<td>Number of Ideas</td>
<td>Non-significant. F(1, 12) = 0.25, p = 0.62</td>
</tr>
<tr>
<td></td>
<td>Time Talking</td>
<td>Non-significant. F(1, 12) = 0.10, p = 0.74</td>
</tr>
<tr>
<td></td>
<td>Idea Quality</td>
<td>Non-significant. F(1, 12) = 0.00, p = 1.0</td>
</tr>
<tr>
<td></td>
<td>Idea Customization</td>
<td>Qualitative differences explored in Results section.</td>
</tr>
</tbody>
</table>

An additional variable, number of words written, was collected in order to assess the effect of participant verboseness on the perceived quality of ideas as determined by expert raters. There was a strong positive correlation between the
overall quality rating of design ideas and the number of words written by participants (r=.856, n=16, p < .001). The five quality ratings made by the design experts on the ideas generated from each group were found to be highly correlated with each other, so only the overall quality rating was used in the above descriptive table. These results and the data analysis will be described in greater detail in the following sections.

5.4.1.1 Findings Relating to Dependent Variables

Although none of the dependent variables were found to be significantly different in a univariate analysis of variance (p > .05), several general observations were made across the four different treatment groups. These observations will be described in the following section, including means plots and boxplots; the findings will be further explored in the subsequent discussion chapter.

For the dependent variable of number of ideas, the guidelines reduced the number of ideas generated by the users and designer groups but not for the groups of designers. For groups of designers only, the number of ideas generated were roughly the same both with (average of 16.75 ideas generated) and without the guidelines (average of 15.75 ideas generated). The groups of users and designers working without the guidelines generated a roughly similar number of ideas (mean of 16.00 ideas), as the designers-only treatment groups. For these groups of users and designers, the use of the guidelines reduced the average number of ideas generated, from 16.00 to 13.25 ideas.
For the dependent variable of *time talking*, the guidelines were shown to increase discussion time only for the treatment group of designers only. In general,
the groups of designers-only, working without guidelines, and all treatment groups of users-and-designers spent roughly the same amount of time engaged in conversation. The groups of users-and-designers spent an average of 487.75 seconds talking when working with guidelines and 483.50 seconds talking when working without guidelines; the groups of designers-only spent an average of 453.25 seconds talking when working without guidelines. When working with guidelines, the groups of designers-only showed an increase in time talking, spending an average of 609.00 seconds talking.

Figure 7: Experiment 1 - time talking
The dependent variable of *word count* measured the number of words written down by participants during the design exercise. The number of words generated were roughly similar across the groups of designers-only working with guidelines (mean of 96.25 words written) and the groups of users-and-designers working with (mean of 108.75 words written) and without (mean of 128.75 words written) the guidelines. However, the groups of designers-only showed an increased word count when working without the guidelines (mean of 170.00 words written). In combination with the findings from the time talking variable discussed earlier in this section, this indicates that the designers-only groups spent more time in discussion when working with the guidelines, and more time writing when working without the guidelines.
Figure 9: Experiment 1 - word count dependent variable

Figure 10: Experiment 1 - boxplot of word count variable
For the *quality* ratings, done by design experts, a 7-point scale of five quality elements was used (section 4.4 Data Collection Instruments). The design experts were either upper-level faculty in human-computer interaction (HCI) or doctoral students in HCI, some with industry experience in design. The raters were given the ideas generated by each group (16 groups in total) and asked to rate them on the five scales. The ratings were collected by the researcher and analyzed for both inter-rater reliability and correlation.

Inter-rater reliability was first assessed using a two-way mixed model, intraclass correlation. Intraclass correlation is used to consistency of ratings across interval scales, such as the ones employed in this study, and indicates reliability measures when multiple judges, in this case five, rate the same items. The intraclass correlation coefficient for average measures was found to be .85, which indicates a high level of agreement (Cronbach’s alpha is .85) between rater across all of the five scales (Table 17 below). The average measure was used so that the average rating, across all five evaluators, could be used in further analyses.

Table 17: Intraclass correlation measuring reliability between expert raters

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.854</td>
<td>.868</td>
<td>5</td>
</tr>
</tbody>
</table>
This indicates that there was generally good agreement between raters on each of the items; but it is also necessary to assess the relationship between the scales themselves. The relationship between detail, completeness, flexibility, originality and overall quality was then investigated.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detail</td>
<td>4.0875</td>
<td>1.16840</td>
<td>2.00</td>
<td>5.60</td>
</tr>
<tr>
<td>Completeness</td>
<td>3.9750</td>
<td>1.28141</td>
<td>2.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Flexibility</td>
<td>4.1875</td>
<td>1.17636</td>
<td>2.20</td>
<td>6.00</td>
</tr>
<tr>
<td>Originality</td>
<td>3.9875</td>
<td>.94789</td>
<td>2.60</td>
<td>5.40</td>
</tr>
<tr>
<td>Overall Quality</td>
<td>4.1000</td>
<td>1.20222</td>
<td>2.20</td>
<td>6.00</td>
</tr>
</tbody>
</table>

A Pearson correlation coefficient was computed to assess the relationship between the five scales used, based on the means of the ratings given by the design experts. All of the five scales were found to be positively correlated with each other (Table 19 below), with the highest positive correlation between overall quality and detail, \( r = .960, n = 16, p = .000 \). This finding indicates multicollinearity, the case in which the dependent variables are highly correlated, with correlations greater than .9 (Pallant, 2001). As shown in Table 19, below, detail and overall quality, in particular, were highly correlated with the other scales and with each other.
Table 19: Correlations between means of quality ratings

<table>
<thead>
<tr>
<th></th>
<th>Detail</th>
<th>Completeness</th>
<th>Flexibility</th>
<th>Originality</th>
<th>Overall Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detail</td>
<td>1.00 (sig .00)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Completeness</td>
<td>.90 (sig .00)</td>
<td>1.00 (sig .00)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flexibility</td>
<td>.91 (sig .00)</td>
<td>.77 (sig .00)</td>
<td>1.00 (sig .00)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Originality</td>
<td>.82 (sig .00)</td>
<td>.66 (sig .00)</td>
<td>.74 (sig .00)</td>
<td>1.00 (sig .00)</td>
<td>-</td>
</tr>
<tr>
<td>Overall Quality</td>
<td>.96 (sig .00)</td>
<td>.90 (sig .00)</td>
<td>.89 (sig .00)</td>
<td>.85 (sig .00)</td>
<td>1.00 (sig .00)</td>
</tr>
</tbody>
</table>

In such a scenario, this can indicate that one of the variables is a combination of other variables. One of the strongly correlated pairs of variables can then be removed from further analysis (Pallant, 2001); for this reason, the detail scale which was highly correlated with several of the scale measures was removed and the correlation test rerun. Table 20, below, represents the correlation between scale means with the detail scale removed. The remaining scales were used for the next steps of the data analysis – assessing the quality ratings for significant differences across the treatment groups.

Table 20: Correlations of quality ratings, with detail removed

<table>
<thead>
<tr>
<th></th>
<th>Completeness</th>
<th>Flexibility</th>
<th>Originality</th>
<th>Overall Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness</td>
<td>1.00 (sig .00)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flexibility</td>
<td>.77 (sig .00)</td>
<td>1.00 (sig .00)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Originality</td>
<td>.66 (sig .00)</td>
<td>.74 (sig .00)</td>
<td>1.00 (sig .00)</td>
<td>-</td>
</tr>
<tr>
<td>Overall Quality</td>
<td>.90 (sig .00)</td>
<td>.89 (sig .00)</td>
<td>.85 (sig .00)</td>
<td>1.00 (sig .00)</td>
</tr>
</tbody>
</table>

A one-way between-groups analysis of variance was conducted to explore the impact of participation and the meta-design inspired guidelines on the quality of the design ideas, as measured by the quality ratings of completeness, flexibility, originality and
overall quality. The following Table 21 summarizes the findings from each of the four ANOVA tests that were run.

Table 21: Results of ANOVA on quality measures made by expert raters

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dependent Variable</th>
<th>Quality Measure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guidelines</td>
<td>Completeness</td>
<td>Non-significant. F(1, 12) = 3.16, p = 0.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>Significantly higher at the p &lt; .05 level in groups working without guidelines. F(1, 12) = 6.47, p = 0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Originality</td>
<td>Non-significant. F(1, 12) = 0.70, p = 0.41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall Quality</td>
<td>Non-significant. F(1, 12) = 2.12, p = 0.17</td>
<td></td>
</tr>
<tr>
<td>Participation</td>
<td>Completeness</td>
<td>Non-significant. F(1, 12) = 0.94, p = 0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>Non-significant. F(1, 12) = 0.39, p = 0.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Originality</td>
<td>Non-significant. F(1, 12) = 0.11, p = 0.73</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall Quality</td>
<td>Non-significant. F(1, 12) = 0.00, p = 1.00</td>
<td></td>
</tr>
</tbody>
</table>

Only one of the dependent variables for quality was found to be statistically significantly different at the p < .05 level; flexibility ratings were shown to be significantly higher in the groups working without the guidelines (F(1, 12) = 6.47, p = 0.02). However, the actual difference between mean scores between the two groups was not terribly different – the groups working with guidelines were rated an average of 3.5, while the groups working without guidelines were rated an average of 4.8. Both means therefore fell generally into the middle of the 7-point scale.

Due to the general non-significant findings and the high correlation between the overall quality measure and the other scale elements, only the overall quality measure was used in further analysis and discussion. The overall quality variable, as discussed, was observed to be slightly higher for all groups not using the guidelines.
The difference was minimal and the mean ratings generally fell into the mid-range of the scale. As detailed earlier, the overall quality rating was made by design experts on a 7-point Likert-like scale. The mean overall quality rating observed was 4.45 for users-and-designers working without the guidelines, and 3.75 for users-and-designers working with the guidelines. For groups of designers-only, the mean rating without guidelines was 4.65, with guidelines the mean rating was 3.55.

Figure 11: Experiment 1 - overall quality variable
The implications of these experiment 1 findings based on the dependent variables of number of ideas generated, time talking, word count and overall quality, will be explored further in the following discussion chapter. The guidelines were, however, shown to be generally helpful for groups of designers-only, in increasing their design-time discussion. As the dependent variables collected were not statistically significantly different between groups, it was necessary to explore the semantic differences between the ideas generated by each group. In addition to the quantitative exploration of the dependent variables, the data were further analyzed using qualitative research methods to describe the differences between treatment groups in more meaningful detail. This analysis yielded an understanding of how the
ideas generated related to meta-design concepts and how these ideas varied semantically between treatment groups.

5.4.1.2 Findings Relating to Qualitative Analysis of Idea Themes

A qualitative analysis on the idea data was undertaken to explore the themes emerging from participants’ ideation. The ideas were explored in more depth, using inductive qualitative analysis to code text and identify themes from the data (Miles & Huberman, 1994), in order to understand the semantic differences between the treatment groups and ensure construct validity. For this portion of the study, the unit of analysis was considered to be one design idea, as identified by the participants (e.g., one sentence or sentence fragment describing a unique idea). The raw data, consisting of the lists of ideas generated by each group, was first analyzed through a process of data reduction in which the text of each idea was iteratively coded to build an understanding of the type of feature or functionality suggested by the participant. The inductive coding scheme developed from this step of the qualitative analysis is shown in Appendix A, with a representative excerpt included below. In order to mitigate the possibility of researcher bias in all steps of the qualitative analysis of idea data, the lists of ideas from all groups were anonymized such that they were not clearly associated with a particular treatment group.
Table 22: Excerpt from experiment 1 coding scheme

- **Layout & Design**
  - Home page has simple search by title/ISBN
  - Interface like Google
  - Large GUI buttons
  - Tabs - trade/buy/browse/register/search
  - Similar design - Amazon
  - Similar design - Ebay
  - Specific home screen setup
  - Simple look and feel
- **Localization**
  - Location for hand-delivery
  - School-specific version
  - Sorting by proximity
  - Google shopping "search nearby"
  - Select location
- **Accessing site**
  - Call-in number
  - Free access

A thematic analysis was then conducted, in order to build an understanding of the predominant themes addressed by participants in their ideas, and the relationships between these ideas. The codes were therefore categorized into themes to capture the patterns within the data (e.g. Layout & Design, Localization, etc.). The following table lists the main themes within the ideas generated by participants, and the respective number of ideas falling into the categories in both the groups with and without guidelines. The full list of codes and themes is shown in Appendix A. As shown below, the most frequent themes included ideas oriented around book metadata, personalization, finding/searching, and purchasing tools and options. As will be discussed further, the themes were not represented equally across the treatment groups working with and without the guidelines.
Although many ideas were common to all treatments (e.g. user profiles, book reviews), several themes emerged as being more common to one or another treatment group (Table 23, above). In order to explore this finding further, the distribution of ideas across the entire list of themes was found to be statistically significantly different in a test of Pearson’s chi-square $\chi^2(17, N=270) = 55.02$, $p <.001$.

Table 24: Experiment 1 - chi-square of differences in ideas themes between treatment groups

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>55.025*</td>
<td>17</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>65.623</td>
<td>17</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>270</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Having assessed that the representation of themes across the groups working with and without guidelines were statistically significantly different, the themes were then related to key meta-design concepts with the goal of building an understanding of whether the guidelines had an effect on shifting design time ideation towards future opportunities for end-user customization. As detailed in the previous literature review, a key principle for the meta-design of socio-technical systems is to provide building blocks for the eventual end users of the system to “freely combine, customize, and improve these components or ask others to do so” (Fischer & Herrmann, 2011). In the final step of the qualitative analysis, the themes were then rated by the researcher across this principle for meta-design, in attempts to understand whether the ideas generated were oriented towards customization in the hands of the future end user, as described by Fischer and Hermann (2011).

Upon iterative analysis of the themes identified by the researcher, the themes naturally fell into a low, medium, or high category with respect to how much, or how little, they facilitated end-user customization. In general, ideas characterized as low customization referred to fixed features with little to no user contribution or customization. Medium ability ideas typically allowed for users to contribute content or customize on a content or display basis. High ability ideas were oriented towards ways of allowing users to customize or extend the website in order to make it functionally different or improved in some way. The themes were then grouped according to their ability to support end-user customization; each theme was ranked high (e.g. “Personalization”), medium (e.g. “Mobile access”), or low customization (e.g. “Book metadata”). Table 25, below, shows the grouping of themes into high,
medium, and low customization. This was accomplished by looking at the ideas that fell within each theme and considering the overall nature of the theme (i.e. – did it refer more to fixed features of the system or to ones where users could contribute or modify in some way?). Themes such as *personalization* naturally fell into the higher customization group, whereas fixed features such as the *technical details* of the system fell into the lower group. Several themes that allowed for a bit of user contribution or adaptation (such as *help* features where users can ask and answer questions) fell into the medium customization group.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Guidelines</th>
<th>No-Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Customization</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Functional Changes)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding/searching</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>Localization</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Personalization</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>Real-time communication</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Recommendations</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Social networking</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>69</td>
<td>44</td>
</tr>
<tr>
<td><strong>Medium Customization</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Display Changes)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course content</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Digital materials</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Helping users</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Layout &amp; design</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Mobile access</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Personal cataloging</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Reputation/trust</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td><strong>Low Customization</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Fixed Features)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessing site</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Book metadata</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td>Marketplace rules</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Purchasing tools &amp; options</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Technical details</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28</td>
<td>64</td>
</tr>
</tbody>
</table>
The distribution of ideas across the treatments working with and without guidelines was found to be statistically significantly different ($\chi^2(2, N=270) = 23.94, p <.001$), with a higher than expected number of ideas relating to high/medium customization in the groups working with the guidelines (Table 25 above).

<table>
<thead>
<tr>
<th>Customization</th>
<th>No Guidelines</th>
<th>Guidelines</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Count</td>
<td>64</td>
<td>28</td>
<td>92</td>
</tr>
<tr>
<td>Expected Count</td>
<td>45.0</td>
<td>47.0</td>
<td>92.0</td>
</tr>
<tr>
<td>Medium Count</td>
<td>24</td>
<td>41</td>
<td>65</td>
</tr>
<tr>
<td>Expected Count</td>
<td>31.8</td>
<td>33.2</td>
<td>65.0</td>
</tr>
<tr>
<td>High Count</td>
<td>44</td>
<td>69</td>
<td>113</td>
</tr>
<tr>
<td>Expected Count</td>
<td>55.2</td>
<td>57.8</td>
<td>113.0</td>
</tr>
<tr>
<td>Total Count</td>
<td>132</td>
<td>138</td>
<td>270</td>
</tr>
<tr>
<td>Expected Count</td>
<td>132.0</td>
<td>138.0</td>
<td>270.0</td>
</tr>
</tbody>
</table>

Furthermore, the groups working without guidelines showed a higher than expected number of low-customization ideas. The following table summarizes the number of ideas falling in the low, medium and high categories across treatment groups working with and without guidelines.

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Low Ability</th>
<th>Medium Ability</th>
<th>High Ability</th>
<th>Total Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Guidelines</td>
<td>28 (20%)</td>
<td>41 (29%)</td>
<td>69 (50%)</td>
<td>138</td>
</tr>
<tr>
<td>W/o Guidelines</td>
<td>64 (48%)</td>
<td>24 (18%)</td>
<td>44 (33%)</td>
<td>132</td>
</tr>
</tbody>
</table>
The implications of these significant differences and the categorization of low/medium/high customization ideas and their relationship to the research questions will be explored further in the discussion chapter.

5.4.1.3 Use of guidelines by laboratory participants

In addition to the raw idea data generated and analyzed, participants were asked to cite the guideline that a particular idea related to, during the ideation process. This served to help determine which guidelines were most useful and whether there were differences across treatment groups working with and without end-user participants. In general, the different treatment groups attributed ideas across guidelines similarly with the exception of guideline #4 (“begin using it quickly”), which was more often used in the groups that included end users (Figure 13). This trend will be discussed further in the discussion chapter.

![Figure 13: Experiment 1 - use of guidelines by treatment groups](image-url)
5.5 Experiment 2/3 Results: Ipl2 design exercise and End-User Diary Keeping

Experiment 2 and 3 sought to explore the effects of meta-design inspired guidelines and desired end user modifications in a real-world context, to assess their usefulness to real-world design practices. In this ipl2 design exercise, a group of designers and end users conducted two, iterative design exercises using the meta-design inspired guidelines. The participants were either designers or real-world end-users of the ipl2 (http://www.ipl2.org), a free digital library. In addition to the design exercise sessions, in between sessions the end user participants kept diaries recording their suggested changes to the system during use.

5.5.1 Research Question 2: Applicability to real-world design

The dependent variables collected in experiments 2 and 3 consisted of the number of ideas generated (both as a group and on an individual basis), the amount of contribution to design discussion by each participant (as measured by total words spoken), and the number of times each guideline was referenced in design discussion. In addition to these measures, inductive qualitative analysis, consisting of coding and thematic analysis, was conducted on the text of the ideas generated in order to build a deeper understanding of the guidelines’ contribution to real-world design processes.

5.5.1.1 Findings related to dependent variables

In the ipl2 design exercise, the number of ideas generated by the group of designers and end-users was 25 ideas in the first session and 21 design ideas in the second session, for a total of 46 ideas. The number of ideas generated individually in the ipl2 design exercise appeared to be related to the amount of design experience of
each participant. More HCI design experience generally meant more ideas generated. Users with less design experience (and the more technically-oriented designers) contributed less ideas overall (Figure 14).

![IPL2 Case Study: Number of Ideas Generated by Participants](image)

*Figure 14: Experiment 2 - number of ideas per participant*

*Word count* from each participant was tallied across the two sessions to assess the individual contribution to design discussion made by each participant. In both sessions, the same experienced designer contributed the most to the design conversation across the entire exercise. The remaining four participants, both designers and end users, contributed roughly similar amounts to the design discussions across both sessions.
The end user participants had varied contributions to the design discussion with one end user providing the least contributions in one session and the other end user providing the second highest contribution to design discussion in the second session. The variation between sessions, in particular with the amount of contributions from the end user participants, seemed to be largely based on personal communication style. Both sessions were conducted with the same participants and the same instructions; the variation in contributions noted seemed to relate to the participant’s volubility in the particular session and whether other participants were monopolizing the conversation, independent of role (i.e. end user or designer).

In general, each guideline was referenced by participants between 3 to 9 times in each session with a generally equal distribution across each guideline and across both design sessions.
As with the laboratory study, “connect” and “adapt” were the guidelines most referenced by participants in the ipl2 design exercise experiment. A few examples of the ideas generated that the participants associated with these guidelines follow:

- “RSS/data modularity” (Adapt)
- “More dynamic Q&A with user interaction, feedback to get answers faster and in a community way.” (Connect)

In order to further understand the role of the guidelines in design discussion, the transcripts were explored in order to assess the number of times the guideline was referenced and who was initiating the discussion (i.e. designers or end users). In the first session, participants directly referenced each one of the guidelines in turn, with both designers and end users initiating discussion relating to the guidelines (e.g. from one end user – “I think relating to adapt it, one thing we talked about earlier would be
RSS and modularity so they can just take that information and cut it out…” from a designer “I think for number 3 like in terms of combining technologies, and I think this is like what we talked about before, like push information…”). A similar trend was noticed in the second session, with each guideline mentioned once and explored by the group, with either an end user or designer initiating the discussion around the particular guideline of interest.

Participants did not run through each guideline in order, rather they would tie the ideas from the guideline to those that were being discussed, in order to justify and explain their argument to the whole design group (e.g. “– I think in terms of ‘adapt to personal needs’ I think people would like to go to the IPL and have their preferences remembered” and “I think to have an idea to ‘combine it with other technologies they use regularly’ like not isolating the IPL content from the rest of their online lives but making it more accessible to the person.”).

5.5.1.2 Findings related to qualitative analysis of ideas generated

The raw data consisting of the text of ideas generated in the ipl2 design exercise was analyzed qualitatively in order to build an understanding of the themes addressed by participants in their proposed design ideas. A process of data reduction was first undertaken to code the concepts addressed in each idea, then a thematic analysis explored the patterns that emerged from the data. Several examples of the ideas generated by participants during the ipl2 design exercise are included in the following table.
Table 29: Experiment 2 raw data - example ideas generated by ipl2 design exercise participants

- “Better search, don't have to select categories”
- “More dynamic Q&A - asking community”
- “Modularized content – widget”
- “IPL mobile apps”

The thematic analysis revealed that the design ideas generated were oriented around several themes, some of which related to current features and functionality and others oriented towards future improvements or new features. The following table summarized the findings in the thematic analysis of the ipl2 design exercise idea data.

Table 30: Experiment 2 themes in ipl2 design exercise ideas generated

<table>
<thead>
<tr>
<th>Theme</th>
<th>Number of Times Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking Questions</td>
<td>15</td>
</tr>
<tr>
<td>New Apps and Platforms</td>
<td>15</td>
</tr>
<tr>
<td>Finding &amp; Searching</td>
<td>9</td>
</tr>
<tr>
<td>User-Contributed Content</td>
<td>7</td>
</tr>
<tr>
<td>Personalization</td>
<td>7</td>
</tr>
<tr>
<td>Real-time Communication</td>
<td>6</td>
</tr>
<tr>
<td>News &amp; History</td>
<td>6</td>
</tr>
<tr>
<td>Social Networking</td>
<td>4</td>
</tr>
<tr>
<td>Layout &amp; Design</td>
<td>4</td>
</tr>
<tr>
<td>Games</td>
<td>3</td>
</tr>
<tr>
<td>Collections</td>
<td>3</td>
</tr>
</tbody>
</table>

The ideas generated by the ipl2 design exercise participants were also evaluated against Fischer and Hermann’s principle of meta-design, as in experiment 1. The goal of this portion of the analysis was to assess the ability of the guidelines to focus the design ideas generated on future customization in the hands of end users.
Out of the total number of ideas generated, across both ipl2 design exercise sessions, as in experiment 1, the low customization ideas were the majority, representing 48% of the total ideas. Medium customization ideas were second, with 41%, with high ability ideas representing 11%. This represented a much different percentage of high customization ideas than in experiment 1, conducted in the laboratory.

Table 31: Experiment 2 - low, medium, and high customization ideas generated

<table>
<thead>
<tr>
<th>Ipl2 design exercise</th>
<th>Low Ability</th>
<th>Medium Ability</th>
<th>High Ability</th>
<th>Total Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22 (48%)</td>
<td>19 (41%)</td>
<td>5 (11%)</td>
<td>46</td>
</tr>
</tbody>
</table>

In general, ideas characterized as highly customizable in the hands of end users, consisted of ideas oriented towards future changes and adaptations to meet emergent needs. Medium customization ideas supported some means of customization, typically adding or modifying content, while low customization ideas referred to fixed features or offerings of the website. Examples of each level of customization are included in the table below.

Table 32: Examples of ideas with low, medium, and high customization

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>“News aggregator”</td>
<td>“Add their own content, web 2.0 style”</td>
<td>“Use the IPL without having to go to the website. Apps-mobile, desktop apps, add-ons to other programs/software”</td>
</tr>
</tbody>
</table>
As mentioned earlier, the five guidelines were used about equally in idea generation. However, all five ideas that were deemed as highly enabling end user customization were noted as relating to guideline 5 (“Adapt it to their personalized needs.”) by the participants.

In the final portion of the design exercise, participants were asked to generate a list of the top ideas that they would like to implement first on the ipl2. The participants were unable to agree on a list of only five ideas, and the below table of seven was generated. The top ideas ranged from improvement to existing features, such as search and interface design, to major features such as integrating IPL with tools outside of the website itself (“Use IPL without going there”) and providing personalization as well as user-generated content.

<table>
<thead>
<tr>
<th>Table 33: List of top ideas for immediate implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• [Improved] Searching</td>
</tr>
<tr>
<td>• Community/user generated [content]</td>
</tr>
<tr>
<td>• Use IPL without going there</td>
</tr>
<tr>
<td>• Design [update and improve consistency]</td>
</tr>
<tr>
<td>• News aggregator</td>
</tr>
<tr>
<td>• Content management system</td>
</tr>
<tr>
<td>• Personalization - desired content</td>
</tr>
</tbody>
</table>

5.5.2 Research Question 3: Desired end user modifications

In the diary keeping study, users of a digital library (ipl2.org) kept a diary of changes they would like to make to the system, while they were using the system. The two end users engaged in diary keeping activities, submitted a total of 20 design
ideas and suggestions over the two weeks between the two sessions. This data was primarily analyzed using inductive qualitative coding and thematic analysis to build an understanding of the key concerns of the end-user participants.

The raw data consisted of a time-stamped list of design ideas suggested by the end-user participants, including details as to what task they were engaged in on the ipl2’s website. The following table includes a few examples of the raw data submitted to the research by the end-user diary keepers, with the full diaries included in Appendix B.

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>What are you doing on the ipl2 right now?</th>
<th>What is the problem or possible improvement?</th>
<th>Do you have any ideas or solutions to this problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/23, 7:30pm</td>
<td>Generally exploring the site, taking a look at areas where I have subject expertise</td>
<td>Not all resources are included in subcategories. Economics is not indexed at all. It’s inconsistent and makes it difficult to find resources on subject pages. Some resources are effectively hidden as a result.</td>
<td>Every area needs to be indexed/have subcategories, and there needs to be a simpler way to sort/see range of results</td>
</tr>
<tr>
<td>2/27 10pm</td>
<td>Writing a scenario using the U.S. Presidents section</td>
<td>Search within the POTUS collection</td>
<td>Allow users to restrict their searches to particular areas of the site</td>
</tr>
</tbody>
</table>

The raw data was analyzed in order to build an understanding of the general themes addressed by the end users in their design suggestions. In general, the ideas generated by end user participants contained few direct suggestions about look-and-
feel. All the ideas were oriented towards more efficient immediate use of the system in the present. Additionally, the majority of the participant suggestions involved functional changes to the system. A few representation examples from the end-user participants are as follows:

- “Allow for a tagging system where a particular resource could have many tags, and thus categorized under many categories.”
- “Allow users to sort and filter results by section of the site”

The majority of the ideas suggested changes to features (or brand new features) that the end users would not have the technical knowledge to implement. Therefore, the ideas were presented on a high level, without including any implementation details. The ideas were all existing concepts, either improvements to existing features or common features on other websites, with no novel concepts suggested. The implications of these findings and their relationship to meta-design systems will be explored further in the discussion section on end-user motivation.

5.6 Conclusion and Main Findings

In experiment 1, neither factor of participation or use of meta-design inspired guidelines showed a significant difference in the number of ideas generated, overall quality of the ideas, or time spent talking. The qualitative analysis of ideas oriented towards customization revealed significantly more ideas oriented around future modifications in the treatment groups using the meta-design inspired guidelines. This is a promising finding that the design ideas generated when using the guidelines are
more oriented towards future customization in the hands of end users, and that design
time thought is focused on such possibilities. Overall, though the results were not
statistically significant, the following observations were made regarding the
dependent variables of number of ideas, time talking, word count, and overall quality rating:

- For the dependent variable of *number of ideas*, the guidelines reduced the
  number of ideas generated by the users and designer groups but not for the
groups of designers
- For the dependent variable of *time talking*, the guidelines were shown to
  increase discussion time only for the treatment group of designers only.
- The groups of designers-only showed an increased *word count* when
  working without the guidelines (mean of 170.00 words written).
- The *overall quality variable*, as discussed, was observed to be slightly
  higher for all groups not using the guidelines; the difference was minimal
  and the mean ratings generally fell into the mid-range of the scale.

In *experiment 2 and 3*, the ipl2 ipl2 design exercise, 46 design ideas were
generated by designers and end users over two design sessions. Those with more
design experience generated more ideas and, overall, the group generated a high
percentage of ideas oriented towards customization by future end users. In
*experiment 3*, the diary keeping by ipl2 end users, participants generated 20 ideas that
were primarily related to functional changes to the system that would improve
efficiency of use and usability in the short term.
The following discussion chapter will discuss the implications and meaning of these findings in greater depth and relate them to the conceptual framework and future vision of meta-design.
6. DISCUSSION

As system designers, the technology tools that we design today will be used in the future. This is a future in which we can make predictions about some, but not all, contexts of use. This gap, between design time and use time, creates a great challenge in how best to design for unpredictable futures. As detailed in the review of literature, when use times were bounded and contained to the workplace, this gap was small and our design time techniques were sufficient. As technology has moved into complex and fluid contexts of use, spanning new devices, behaviors, tools and cultures our design methodologies have not kept pace with these trends.

The framework of meta-design suggests developing systems that are continuously co-designed during use, throughout the life of the system. This framework needs to be extended to practical methods which can help today’s meta-designers create the tools for future end users to create and design their own environments. In pursuit of such a future, the following four research questions were explored in the series of experiments aimed at focusing design time work towards future unanticipated scenarios of use:

*RQ1-A: What is the effect of meta-design inspired guidelines on the design ideas generated during design activities?*

*RQ1-B: What is the effect of end user participation on the design ideas generated during future-focused design activities?*
RQ2: Can meta-design inspired guidelines provide a useful framework for focusing continuous and participatory real-world design time activities on future scenarios of use?

RQ3: What types of changes might end users want to make to systems during real-world use?

This chapter will explore the results in greater depth, as related to themes addressed by the above research questions, with a strong focus on research question 3 which relates to moving meta-design concerns into real-world design activities. The remainder of the chapter is structured as follows:

6.1 Summary of Results

6.2 What is the value of the meta-design inspired guidelines and end user participation in design-time idea generation?

6.3 How can quality be measured in meta-design systems?

6.4 How much end-user customization is desirable in a meta-design system?

6.4.1 How can we characterize end-user customization in our current technologies?

6.4.2 What is an appropriate ratio between low, medium, and high customization features?
6.5 Can such a meta-design inspired process contribute to real-world design activities?

6.6 What have we learned about end user motivation to contribute to systems?

6.7 What role do individual differences play in end user motivation?

6.8 Summary of Discussion

6.1 Summary of Results

*Experiment 1*, the laboratory study, yielded some unexpected findings. Although the different treatment groups came up with roughly the same number of ideas with the same level of quality and spent the same amount of time talking (none of these variables was statistically significantly different), the concepts covered in the ideas differed, with groups using the guidelines focusing more on ideas to facilitate customization in the hands of end users. The guidelines were generally found to help groups of designers more than designers-and-end-users, in facilitating discussion and design ideas. The quality measures used, which were intended to be oriented towards meta-design values, were found to be highly correlated amongst each other and therefore not usefully descriptive of the variation between the designs; there was also no statistically significant difference in quality among the four treatment groups.

In *experiments 2 and 3*, oriented towards real-world use, the meta-design inspired guidelines were used in an iterative design exercise with designers and end users of the ipl2 (www.ipl2.org), a digital public library. The guidelines were found to be
useful in sparking design discussion and design ideas, with many ideas focused on providing customization tools for future end users of the system. In experiment 3, the end users that participated in this ipl2 design exercise, also kept diaries recording changes they would like to make to the system while they were using it in real-world design activities. These design ideas from the end users tended to focus on immediate improvements to the system that would provide features to increase the efficiency of use of the ipl2.

These results lead us to ask several questions exploring these findings in greater depth and relating them to the goal of building a practical understanding of meta-design as continuous participatory co-design. First, it is necessary to understand the contribution of the guidelines by asking – what is the value of the meta-design inspired guidelines and end user participation in design-time idea generation? In pursuit of this understanding, additional questions are raised such as: how do we measure quality in meta-design systems? And just how much end-user customization is desirable in such systems? Finally, what have we learned about end-user motivation to contribute to systems and what role do individual differences play? Each of these questions, and relevant sub-questions that emerge, will be discussed in greater detail in the following sections.

6.2 What is the value of the meta-design inspired guidelines and end user participation in design-time idea generation?

The factors of meta-design inspired guidelines and end user participation were not found to yield statistically significant differences in the number of ideas generated, participant time talking, or quality of design ideas generated in a univariate analysis
of variance (p > .05). A few trends were observed: the guidelines reduced the number of ideas generated by groups of users-and-designers, increased talk time for groups of designer-only, and yielded no difference in idea quality as measured by raters. These trends and their implications will be discussed further in this section.

For the dependent variable of number of ideas, the guidelines were found to reduce the number of ideas generated by the users and designer groups but not for the groups of designers. This may be because those with more design experience are more capable of taking abstract guidelines and expanding these into real design ideas or using them as a basis for design discussion. The design task for the laboratory experiment consisted of designing a “textbook trading website” that college students would use to exchange textbooks. This was chosen as it was general enough to be a familiar concept to the participants, as they were all students, but likely a tool they did not have extensive experience using already so it would require some thought as to the features and functionality it would contain. As this may not be a domain in which they had extensive experience, the guidelines may have been more help to designers who could generalize and extend them to implementable ideas, as opposed to groups including end users who may have had less experience designing for new domains.

For the dependent variable of time talking, the guidelines were shown to increase discussion time only for the treatment group of designers-only, with no effect on the groups of designers-and-users working with the guidelines. However, the groups of designers-only showed an increased word count when working without the
guidelines. This indicates that groups of designers-only likely spent more time in discussion and less time writing down ideas when working with the guidelines. In this study, where the unit of analysis consisted of one idea as written down by participants, this trend may have detracted from the measurable output of these groups in words written and number of ideas. In the context of real-world design, encouraging brainstorming and design-related conversation between designers is a desired outcome of use of the meta-design inspired guidelines. As these groups ultimately generated more ideas focused on customization, as a goal of meta-design systems, this increased discussion time may have productively focused the designers on future contexts of use. Therefore this finding is promising as to the potential of using such guidelines in design-time ideation, but requires further exploration to understand whether such increased discussion is an efficient use of time.

Interestingly, a similar effect was not observed with the groups of users-and-designers; the use of the guidelines did not change the amount of time spent talking or the word count generated in these groups with less design experience. This may be because these groups were less skilled at utilizing guidelines or heuristics in their design processes or simply had less experience designing overall. In the present, such design activities are still largely carried out by skilled designers, therefore the successful results with the designers are promising. In the future, the line between designers and users will continue to blur and such methods must ideally be as relevant to designers as to end users. Both designers and end users must participate in envisioning future contexts of use and potential for end-user customization. While the guidelines appeared to be well-understood and used by participants with varying
design experience, it is worth further exploration to build an understanding of how the guidelines can better assist unskilled designers.

Finally, the overall quality variable, as discussed in the previous results section, was observed to be slightly higher for all groups not using the guidelines. The difference was minimal and the mean ratings generally fell into the mid-range of the scale. As discussed earlier, the quality ratings were done by design experts on a 7-point scale of five quality elements. The design experts were either upper-level faculty in human-computer interaction (HCI) or doctoral students in HCI, some with industry experience in design. The raters were given the ideas generated by each group (16 groups in total) and asked to rate them on the five scales. The five scales given to the raters were as follows (the complete data instrument can be seen in section 4.4 Data Collection Instruments):

Table 35: Experiment 1 quality rating scales

| Level of Detail | How low-level and non-vague are the elements of the design? |
| Completeness    | How complete is the design? Does the design contain all the necessary parts that it will need to work? |
| Flexibility     | How much of the design can users personalize, contribute to, or otherwise modify? |
| Originality     | How novel is the design? Does the design seem new or surprising in any way? |
| Overall Quality | Overall how good of a solution is the design? |
The ratings were collected by the researcher and analyzed for both inter-rater reliability and correlation. A Pearson correlation coefficient was computed to assess the relationship between the five scales used, based on the ratings given by the design experts. All of the five scales were found to be positively correlated with each other (table 19 in section 5.4.2 above), with the highest positive correlation between overall quality and detail, \( r = .960, n = 16, p = .000 \). This high level of correlation between scale ratings can indicate that one of the variables is a combination of other variables (Pallant, 2001). Additionally, only one of the quality measures was statistically significant between groups (flexibility was significantly higher in the groups working without guidelines), but even these means fell relatively close together in the middle of the scale (mean rating of 3.5 with guidelines vs. 5.8 without guidelines). Therefore none of the quality ratings done by experts were of particular use in building an understanding of the quality of a meta-design system. This challenge, to effectively understand and measure quality as related to meta-design values, will be discussed further in the next section.

6.3 How can quality be measured in meta-design systems?

Assessing quality of the design ideas generated by participants in experiment 1 was a challenge; although prior research has explored scales for evaluating design quality there is little agreement on how to measure or define quality in this context. Meta-design systems provide a unique quality measurement challenge in that many of the meaningful dimensions of a successful meta-design system emerge slowly, over
time, and with use. Such longitudinal dimensions are not easily, or possibly, distilled into simple measures that may be conducted at design time.

In order to begin to build an understanding of how to assess, even in part, the quality of a meta-design system, a review of existing scales in design and creativity literature formed the basis of the scales used in this study (included in section 4.4 “Data Collection Instruments). In general, design literature tended to focus on measuring detail, completeness and quality (e.g. Chung et al., 2004; Saponas, Prabaker, Abowd, & Landay, 2006) or used established methods from usability to assess design quality (e.g. heuristic evaluation). Literature on the design and creativity side focused on ideation and the outputs of such activities. The most common measurements used to assess problem solving creativity included fluency (number of ideas generated), originality, and flexibility; these measures are derived from early research on intelligence and creativity (Guilford & Hoepfner, 1971). These three measures were most commonly used to judge quality in the output of design ideation (e.g. Cheung, Rudowicz, Yue, & Kwan, 2003; Vosburg, 1998). These three measures were often combined with, or replaced by, other measures such as usefulness (e.g. Vosburg, 1998), elaboration (e.g. Guilford & Hoepfner, 1971), value (e.g. Massetti, 1996), and validity (e.g. Kiyokawa, Washida, Ueda, & Peng, 2009); these measures were found to be less common and were therefore not used in this study. The scales used in this study (summarized in table 36 below) were based on previous work, in order to both build on known successful scales and to avoid introducing additional unknown variables to the study.
Table 36: Scales used in quality assessment

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Related Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Detail</td>
<td>How low-level and non-vague are the elements of the design?</td>
<td>(Saponas, et al., 2006)</td>
</tr>
<tr>
<td>Completeness</td>
<td>How complete is the design? Does the design contain all the necessary parts</td>
<td>(Saponas, et al., 2006)</td>
</tr>
<tr>
<td></td>
<td>that it will need to work?</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>How much of the design can users personalize, contribute to, or otherwise</td>
<td>(Guilford &amp; Hoepfner, 1971)</td>
</tr>
<tr>
<td></td>
<td>modify?</td>
<td></td>
</tr>
<tr>
<td>Originality</td>
<td>How novel is the design? Does the design seem new or surprising in any way?</td>
<td>(Guilford &amp; Hoepfner, 1971)</td>
</tr>
<tr>
<td>Overall Quality</td>
<td>Overall how good of a solution is the design?</td>
<td>(Saponas, et al., 2006)</td>
</tr>
</tbody>
</table>

Although these were common scales in previous literature, the ratings made by participants on the various scales were highly correlated, as detailed in previous results chapter. There was also only one significant difference noted, in flexibility between groups with and without guidelines, across the different treatment groups. This indicates that raters may have had difficulty distinguishing between the scale concepts, or that they were naturally linked, and were using a more general idea of overall quality to assess idea quality. Additionally, the lack of statistically significant difference between treatment groups in quality made it difficult to determine what the differences were between the design ideas generated by the different treatment groups.

The scales might have been more useful and yielded stronger differences between treatment groups if there had been a larger data set. Such scales require significant
time for raters to familiarize themselves with the scales and to review the data and conduct the rating. Therefore, such scales do not extend well to larger data sets. Another possible issue is the format of the raw data as lists of ideas in text format. A richer representation form, such as prototypes or sketches, may have better helped the raters to envision the resulting system and the implications of the design ideas generated by participants. An unintended consequence of the failures of the quality ratings was a need to conduct further qualitative analysis on the idea data generated. This yielded a richer understanding of the themes in the idea generated, their relationships to the treatment conditions, and began to build an understanding of the ideal amount end-user customization in meta-design systems.

And ultimately, measuring success of a meta-design system is not simply a technical challenge (e.g. developing the correct measurement scales) rather there is a strong social element as well. A meta-design system is modified by its end users on a variety of levels – from content addition to functional tool development – success must be measured not only in how well the system technically facilitates such changes but also on the activity and involvement of its users. Taking Google’s SketchUp (a freely available 3D modeling software program) as an example of a successful meta-design system, there is a deeply involved community as well as a technical framework in place for customizing and extending. At the content level, the system is used by “a community of over two million active and engaged users a week, who talk to one another, solve problems, share models, and techniques” (Bacus, 2011). An open scripting Ruby API provides an opportunity for the system to be
customized, over a thousand such tools exists and 45% of SketchUp Pro (the paid version of the software) users have installed such extensions (Bacus, 2011).

This dissertation work can contribute to such future successful meta-design systems by assisting in anticipating future customizing needs and providing useful tools, such as those included in the Ruby API for SketchUp. These needs occur over time and over space; SketchUp did not develop a rich community overnight. Therefore many of the measures of meta-design success are inherently social and bounded in future use. This presents a challenge to defining success in such a context. The scales developed assessed some dimensions of meta-design systems that appeared to be meaningful and useful, but as discussed above, they were not a good distinguisher of quality in the design ideas developed by participants during this study. Future work can help build an understanding of how existing meta-design systems, such as SketchUp, perform on such a scale and whether such an approach might be of use in evaluating meta-design systems at their inception.

6.4 How much end-user customization is desirable in a meta-design system?

An important question in current meta-design research addresses the ideal amount of end-user customization in a successful meta-design system, in order to facilitate continuous co-design. A number of dimensions come into play when exploring this question, such as the desired balance between system flexibility and rigidity, the motivation of end-user designers, and the potential learning curve, among others. As a continuation of the previous work in experiment 1 exploring the potential for meta-design oriented quality scales, a qualitative analysis to explore the
idea themes and end-user customization was conducted. Part of this analysis was focused on understanding where the participants’ ideas fell on a customization continuum, based on a key principle for the meta-design of socio-technical systems as described by Fischer and Herrmann (2011). This principle emphasizes that successful meta-design systems must provide building blocks for the eventual end users of the system to “freely combine, customize, and improve these components or ask others to do so” (Fischer & Herrmann, 2011). In the final step of the qualitative analysis, the themes were then rated by the research across this principle for meta-design, in attempts to understand whether the ideas generated were oriented towards customization in the hands of the future end user.

6.4.1 How can we characterize end-user customization in our current technologies?

The previous exploration of the customization levels yielded both an understanding of the degree to which the participants’ design ideas supported future end-user customization, which will be discussed further below, but also a description of how our current technologies support such meta-design features and to what extent. This begins to explore the question of – how can we characterize end-user customization in our current technologies? Upon iterative analysis of the themes identified by the researcher, the themes naturally fell into a low, medium, or high category with respect to how much, or how little, they facilitated end-user customization. In general, ideas characterized as low customization referred to fixed features with little to no user contribution or customization. Medium ability ideas typically allowed for users to contribute content or customize on a content or display
basis. High ability ideas were oriented towards ways of allowing users to customize or extend the website in order to make it functionally different or improved in some way. The following table summarizing these findings and provides several examples of each level of customization. Themes such as personalization naturally fell into the higher customization group, whereas fixed features such as the technical details of the system fell into the lower group. Several themes that allowed for a bit of user contribution or adaptation (such as help features where users can ask and answer questions) fell into the medium customization group.

<table>
<thead>
<tr>
<th>Customization Level</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Fixed features</td>
<td>“Book metadata”</td>
</tr>
<tr>
<td>Medium</td>
<td>Display or content changes</td>
<td>“Mobile access”</td>
</tr>
<tr>
<td>High</td>
<td>Functional changes</td>
<td>“Personalization”</td>
</tr>
</tbody>
</table>

This breakdown of end-user customization in the technology used in the experimental design activities is interesting and relevant to meta-design on several dimensions. Most importantly, this indicates that the vision of meta-design systems is beginning to be realized in common systems used on a daily basis. None of the experiments focused on a rare or intentionally end-user-creativity-focused domain, rather the design activities were oriented towards typical systems that might be used on everyday tasks such as information seeking (the ipl2 digital library in experiment 2/3) or purchasing a book for school (the “textbook trading” website in experiment 1).
Secondly, as will be discussed further below, all groups were able to brainstorm design ideas falling into each category, this includes the groups of designers-only and also the groups of designers-and-users. This indicates that not only is end-user customization becoming commonplace, but it is also expected and desirable by users with a varying level of design and development experience. Even those with little technical knowledge can envision ways in which technology systems might be modifiable by future end-users. This finding has significant implications for the motivations of end-user designers, as will be discussed in section 6.6.

Finally, the design ideas generated, even the highest customization ones, were all oriented towards end-user development with the understanding that these would be intermediate tools provided to end-users by designers. These tools would occupy the higher (if not highest) levels of a multi-tier software system architecture. None of the ideas suggested giving end-users direct access to lower levels of the system (i.e. programming or providing APIs). This has interesting implications for the future of meta-design and the role of the “meta-designer”. A future of meta-design assumes that some design work must be conducted at design-time by one or more dedicated designers. In doing such work they will be, directly or indirectly, envisioning the future life of the system in the hands of its end users. All design work is necessarily bounded by multiple real-world constraints (e.g. time, resource availability, project scope, etc.). Becoming a meta-designer cannot be as simple as giving future end-users the potential to design all possible environments; the environments designed by future end-users are bounded both by practical concerns and by the imaginations of the meta-designers. As a fluid and ongoing co-design process, this system evolution
can become a conversation over time, and over multiple designers and users. With such a model of meta-design, the design ideas generated by meta-designers are of upmost importance in facilitating future modifications by end-users. This requires an understanding of what functions such customization tools should support and how they should be represented proportionally to the more fixed features of the system.

6.4.2 What is an appropriate ratio between low, medium, and high customization features?

Looking at the ratio of ideas oriented towards the different levels of end user customization in all phases of the study yields some interesting findings and further questions. As detailed in table 38 (below), the use of the guidelines, laboratory experiment, and real-world context all had a different ratio of low, medium, and high customization ideas. As described above, low customization ideas referred to fixed features, medium customization ideas typically address content or display modification, while high customization ideas allowed functional changes to be made to the system by end users.

<table>
<thead>
<tr>
<th>Table 38: Low/medium/high customization ideas generated in each experiment</th>
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<tbody>
<tr>
<td><strong>Experiment &amp; Treatment Group</strong></td>
</tr>
<tr>
<td><strong>Experiment 1:</strong></td>
</tr>
<tr>
<td>- With Guidelines</td>
</tr>
<tr>
<td>- W/o Guidelines</td>
</tr>
<tr>
<td><strong>Experiment 2:</strong></td>
</tr>
<tr>
<td>- Ipl2 design exercise</td>
</tr>
</tbody>
</table>
The comparison in the above table yields several interesting observations. Firstly, in the laboratory experiment 1, the guidelines shifted the ideas generated towards medium (29%) and high (50%) customization, and away from low customization (20%). The conditions without guidelines had a much higher rate of low customization ideas (48%). As the chi-square test revealed these differences were significant, indicating the guidelines were effective in shifting design-time thought towards future opportunities for user customization.

In contrast, the real-world ipl2 design exercise had a much lower percentage of higher customization ideas (11%). The primary differences between the laboratory experiment and the ipl2 design exercise consist of the choice of participants and the design activity. The laboratory study used experimental participants with general knowledge of the problem domain and often little experience with design. The ipl2 design exercise, in comparison, used a highly skilled group of designers and relatively knowledgeable end users, all of whom often had extensive experience working with the system. Furthermore, the laboratory study task consisted of designing a new system, while the ipl2 design exercise focused on an iteration of an existing system.

The ipl2 design exercise explored a scenario closer to real-world use, in which designers (and end users) are likely to be more experienced with the system to be designed and are often working on iterations on an existing system, as opposed to a brand new system. In the ipl2 design exercise as well, a thematic analysis of the ideas generated indicated a preference towards ideas facilitating customization and content contribution by end users. As the ipl2 design exercise focused on an existing system
versus a new system in the laboratory study, there may have been more mundane ideas that the laboratory participants focused on first in order to endow their new system with basic functionality.

It remains an open question in meta-design systems as to how to create (and maintain) the right balance between highly modifiable and fixed elements of the system. A healthy and usable system must no doubt contain features from both ends of the spectrum, but too fixed may become overly rigid and highly modifiable may become unusable. As the ratio of ideas generated indicate, a system may require a great number of low-modifiable and mid-level content modifiable ideas, with only a few allowing for higher modifiability.

In real-world design, the iterative design approach to an existing system is a far more common occurrence then designing a brand new system. Even in new product development there is often significant borrowing of previously existing ideas and feature sets (e.g. Petroski, 1992). When iterating on a current system, there seem to be a few inhibiting factors in place. First, design teams are somewhat limited by existing features, processes, and designs. Unless significant resources are available, a full redesign is often out of scope for immediate work. Secondly, while meta-design oriented features have begun to be commonplace in our current technologies, there are still relatively few systems designed explicitly for end-user contribution and modification. Therefore the system being iteratively designed, such as with the ipl2 ipl2 design exercise, may incorporate some meta-design oriented features on the
lower end of customization but may not have a suitable framework in place for building in more extensive meta-design oriented features.

Although the ipl2 design exercise participants brainstormed several higher customization ideas, these were not well-represented in the list of ideas they would have liked to implement immediately. As always, design is a process of checks and balances, with numerous constraints. The guidelines may have assisted the designers and end-users in exploring possible future meta-design directions for their system, but if they are not technically feasible in the present, what value do they have? This may be an ongoing tension in meta-design, but as our technologies evolve to make these meta-design features more commonplace this issue may be of less importance.

6.5 Can such a meta-design inspired process contribute to real-world design activities?

The goal of experiments 2 and 3 was to explore the use of the meta-design inspired guidelines in an environment closer to real-world design, through using actual designers and end users of a digital library system (ipl2). The intention was to assess whether such a process might be suited to real-world design ideation. In general, the meta-design inspired guidelines seem well-suited to the ipl2 design team’s ideation process. Key measures of success in this phase of the study related to the understandability of the guidelines (i.e. was the wording and intention of the guideline clear to all participants?) as well as usefulness (i.e. did participants reference each guideline and employ it in generating design ideas?).
The guidelines seemed to be generally well-understood by both designers and end-users engaged in the design activity. This was measured by observing whether the participants expressed confusion about a particular guideline’s meaning or asked clarifying questions, either to each other or the researcher, during the design activities. At no point during the two design sessions did any participant appear to struggle with the meaning or wording of any of the guidelines. A similar observation was made during the previous laboratory experiment as well.

When assessing usefulness, as discussed in the results section, both end users and designers were observed to reference the guidelines during design discussion and relate them to the ideas generated. The guidelines were not typically repeatedly referenced; rather they would be used to initiate a design discussion that would explore potential design ideas relating to the concept. As detailed in the results sections, each guideline was used to generate between 3 and 9 design ideas in each session, with a generally equal distribution across each guideline and across the two design sessions. Additionally, the five guidelines appeared to relate to all the design ideas generated. All of the design ideas generated were reported to relate to one or more of the guidelines, by the participants.

Overall, the guidelines were observed to be written at a level that was easily understood by both those with and without formal design experience. All of the guidelines seemed to have a place in design discussion, with each one being used roughly equally in design ideation. The guidelines mapped well to design ideas both in the context of the laboratory study exercise and in a real-world design problem, in
redesign of the ipl2. Furthermore, the guidelines appeared to be sufficiently flexible to frame design discussion without being explicitly grounded in specific, current technologies. Throughout the series of experiments, both in the laboratory and real-world contexts, design ideas were suggested that covered a range of technologies, both old (e.g. desktop applications) and new (e.g. cell phone barcode scanning). These promising findings indicate that the guidelines likely have the necessary flexibility and generalizability to support and encourage design ideation in a variety of real-world design domains.

6.6 What have we learned about end user motivation to contribute to systems?

As discussed in the previous section, the guidelines facilitated design ideation and discussion for both designers and end-users, with varying levels of formal design experience. This was observed most strongly in the ipl2 design exercise, where the end users and designers were observed to reference the guidelines and contribute to discussion and idea generation about equally. Additionally, both designers and end users were able to brainstorm design ideas that supported a range of end-user customization tools, in all phases of the study.

The end users in the ipl2 design exercise were real end users of the system and therefore are of most interest in exploring end-user motivation to contribute to system design. These end users were generally well-versed in the system and its current functionality. This likely put them in a position to contribute on equal ground with the designers of the system, both in design ideation and in design discussion.
These findings have implications for the overall concept of meta-design; systems that are continuously co-designed must have end users willing and able to be active contributors. As discussed in the review of literature, this shift requires a cultural change towards Alexander’s vision of an “unselfconscious culture of design” (1964) in which end users feel confident and knowledgeable enough to contribute changes to their designed environments. This familiarity with the system may, in reality, already be commonplace with our current technologies, as end users acting as potential designers are likely already building a deep familiarity with the system through using it in their daily activities.

The diary keeping exercise, as well, helps build an understanding of end-user motivations to contribute to design. The end users that participated in the diary keeping exercise suggested changes to features to improve the immediate efficiency of use of the system. These suggestions were highly practical and very focused on the present state of the system. A few suggested larger features that would be new additions to the website (e.g. tagging systems or RSS feeds). All these changes were based around real-world use; these end users were engaging in tasks and activities necessary to their daily lives. These were not contrived tasks or scenarios such as in a formal usability test. All the ideas referred to features that the end users did not have the technical knowledge or skills to implement. In none of the ideas were any technical details to any solutions suggested. Furthermore, the ideas were all existing concepts, either improvements to existing features or common features on other websites, with no novel or new concepts suggested.
These end users were not suggesting innovative changes; rather, these were small-scale iterative improvements to the system voiced during use. And, the end user participants were not shy about voicing their opinions on what could be improved. Usability techniques, which have been a commonly used evaluation technique for many years both in industry and research, are built on similar feedback from end user participants. In essence, the ideas generated by the end user participants were not vastly different from those that may have emerged during a usability test given the same scenario. The difference is that these ideas were generated in the context of real-world use, on the end user’s real time, and outside of the immediate view of researchers and designers. These problems and suggestions might indeed have emerged during a traditional usability test. But such an environment cannot account for the emergent, situated nature of real-world contexts.

In these real-world contexts, the issue of end-user motivation raises additional questions as to how to build our understanding and definition of an ideal meta-design system. As discussed earlier, the ideal relationship between flexible and fixed features in a successful meta-design system remains to be determined. Similarly, the relationship between those acting as users and designers of a meta-design system at any one point in time, must be explored further.

In all phases of the study, a great deal of variation was observed in participant creativity in design ideation. A common definition of creativity comes from Csikszentmihalyi, who maintains that “Creativity is any act, idea, or product that changes an existing domain, or that transforms an existing domain into a new one”
In the creativity literature, a distinction is often made between this big $C$ creativity, in which “extreme forms of originality” are expressed, and little $c$ creativity, for “everyday creativity” (Fasko, 2006). Big and little $c$ creativity therefore form the two poles of a continuum within which all design activities fall.

In respect to meta-design systems, that must continuously be co-designed, end-user creativity is closely entwined with end-user motivation. An ongoing balance must be maintained between those modifying the system and those simply using existing features and tools. A system in which every user acts as a “big D” designer, practicing extreme forms of original design, is likely not sustainable or even possible. Rather a balance must be struck between the more original design changes and the more commonplace everyday design improvements. Findings from this study, in particular from the diary keeping exercise, indicate that the majority of design ideas suggested by end users may fall into the “everyday” design category, focused on making incremental improvements to existing system features. This suggests that, while end users may usefully contribute to system co-design on an ongoing basis, great leaps in design are more likely to be driven by actions and innovations of more experienced designers.

In summation, in both the diary keeping study and the ipl2 design exercise including end users, lack of end user motivation was a non-issue. The participants were confident, willing contributors to their technological environments. Of course, these were participants who had volunteered for the research study and who were being compensated for their time. As discussed, the issue of end-user motivation is
complex and a controlled research study such as this may have limited our understanding of end-user motivation. It also bears noting that the conversational channels between end users and designers were not open during real world use. The system, as it stands, was not able to be modified to support their needs that emerged during use. A traditional participatory design process may have explored some of these needs and built them into the system. But undoubtedly many of these needs would not be known until use time. As meta-designers, we must become better not at predicting future contexts of use, but of predicting tools that may be of use to future modifiers of the system. These tools, combined with opening channels for continuous co-design between designers and users, can empower end users to modify systems in use, both directly and indirectly.

6.7 What role do individual differences play in end user motivation?

Finally, individual differences may have played a role in many of the findings discussed in this chapter, including end-user motivation. Some participants were simply more willing to engage in extensive conversation and brainstorming around the guidelines than other participants, regardless of their level of design experience. This effect of individual differences has been extensively studied in prior research in cognitive psychology (e.g. Guilford, 1967; Guilford & Hoepfner, 1971), with the goal of building a model to understand the primary mental abilities that can be used to characterize individuals (e.g. Thurstone, 1938). Many of these aptitudes are directly related to skills employed by the individuals that participated in this series of experiments (e.g. word fluency, verbal comprehension) and the general process of
brainstorming, around design or in any other domain. More generally, this ongoing research on individual differences has shown that human intelligence is incredibly complex, with many dimensions that are not easily categorized or measured.

Not surprisingly, the effect of individual differences on empirical studies has implications for human-computer interaction research as well. Findings from cognitive psychology have been employed to build our understanding of the human characteristics that are relevant to interface design, testing, and use (Dillon, 1996). This work continues to the present with a great body of research in HCI exploring the effect of user characteristics in a variety of contexts, from understanding information seeking behavior on computing systems (e.g. Palmquist & Kim, 2000), to improving efficiency of use of new devices and interactions (e.g. Arninga & Zieflea, 2009), to conducting design evaluation (e.g. Linga & Salvend, 2009), among many other research threads.

In relation to this study, individual differences are particularly meaningful in the context of the first experiment in the laboratory, in which design experience was controlled for. As the results indicated, although several overall trends were observed, there was not a significant effect of either factor of use of the guidelines or participation of end users. In particular, there was observed to be a large range in a few of the dependent variables such as time talking and word count, variables which described the amount that the participants spoke out loud or wrote, respectively. Both of these measures can be considered to be related to individual characteristics, such as a general propensity to verboseness. These individual differences may have directly
affected the outcome of the study and blurred the distinction between the various treatment groups; this will be discussed further in the limitations section of the following chapter.

However, general trends were still observed which were of interest to this study. The subsequent experiments 2 and 3 based on a real-world design study were undertaken to build a deeper understanding of the use of the guidelines and an understanding of end-user motivation. In real-world systems, the effect of individual differences is lessened by the sheer numbers of end users and potential designers of a system. As discussed earlier, not all end users should act, or want to act, as designers at any given point in time. Therefore, individual differences may be of most relevance to meta-design in allowing end users with the suitable characteristics and motivations to contribute to design to actually bring their design ideas to life.

6.8 Summary of Discussion

The framework of meta-design (Fischer & Giaccardi, 2006) provides a powerful vision of a future in which we are all designers of our technology. Empirical work is needed to build a practical understanding of how meta-design might be conducted in real-world contexts and to further research agendas in the area. The series of research studies discussed in this chapter have begun to explore some “discount” methods of focusing design-time thought on future, unpredictable contexts of use through meta-design inspired guidelines used in design ideation.

As explored in this chapter, the meta-design inspired guidelines were found to be well-understood by experimental participants, in both a laboratory and real-world
context, and used to spark customization-focused design ideas oriented towards future end-user crafters. The real-world ipl2 design exercise yielded a deeper understanding of end user motivation, the ideal balance between system flexibility and rigidity, and the appropriate ratio of designers to users in a successful meta-design system. These findings began to build an understanding of the research questions addressed in this work, as well as suggested many further avenues of exploration and open questions. The next chapter will provide a conclusion and plans for future research, in pursuit of these new questions.
7. CONCLUSION

In the previous chapters, we have shown the historical and theoretical progression of the place and focus of design activities and related this trend to the framework of meta-design and the vision of continuous co-design. Having identified a gap in this framework between theory and practice, a series of three experiments were designed and conducted, aimed at answering four research questions exploring the effect of meta-design inspired guidelines and end user participation in both a laboratory and real-world context.

The meta-design guidelines were found to help facilitate design discussion for groups of designers, and, for participants of all levels of design experience, to shift the design ideas generated towards tools supporting end-user customization. The guidelines performed well in a real-world ipl2 design exercise focused on a redesign of the ipl2 digital library (http://www.ipl2.org), assisting designers and end users in generating future-focused design ideas and discussion. The previous discussion section explores these findings in greater depth, expanding upon how they help us understand the value of such meta-design inspired guidelines in real-world contexts, how to measure quality in meta-design systems, how much end-user customization is desirable and how to characterize it, and the motivations of end-user customizers.

While the findings from this series of experiments make a meaningful contribution to the study of meta-design, they are also only the beginning of the long and complex road towards true meta-design systems that can be continuously co-designed in use. The following section draws some conclusions from the research
findings of this dissertation, discusses the study limitations, and sets a direction for future work in the area of meta-design. The remainder of this chapter is organized as follows:

7.1 Implications for Practice and Research

7.2 Limitations

7.3 Future Work

7.4 Moving Towards a Future of Design-in-Use

7.1 Implications for Practice and Research

The findings in this series of experiments, as explored in depth in the discussion chapter, have important implications for both research and practice in the area of meta-design, specifically in building our understanding of the process of continuous co-design. The remainder of this section describes these implications in greater depth; these themes are continued in the Future Work section and summarized in the table that follows:
Table 39: Summary of implications for research and practice

<table>
<thead>
<tr>
<th>Research Work</th>
<th>Finding</th>
<th>Implication(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Defining characteristics of a meta-design system as related to customization</td>
<td>Build a shared understanding in research work of how to characterize and define a meta-design system, by utilizing the customization variable</td>
</tr>
<tr>
<td></td>
<td>Assessing the quality of a meta-design system is difficult over time and space</td>
<td>Begins to explore and reject some dimensions of measurement – chosen measures did not prove meaningful and suggests further work in this area</td>
</tr>
<tr>
<td></td>
<td>End-user design suggestions oriented around practical, immediate solutions</td>
<td>Raises additional research questions as to how encourage end user contributions in greater depth and what tools to open these channels of communication during use time</td>
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</table>

<table>
<thead>
<tr>
<th>Application to Practice</th>
<th>Designers working with other designers were the most effective at utilizing guidelines</th>
<th>Skilled designers play an important role in providing future opportunities for end-user customization; may be more effective at anticipating needs then end-user contributors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guidelines shift ideas towards end-user customization</td>
<td>Guidelines can be an effective approach to encourage customization features; guidelines likely need further iteration and improvement but are useful for meta-designers in their existing state</td>
</tr>
<tr>
<td></td>
<td>End-users effective contributors of ideas for future customization</td>
<td>Guidelines can provide useful framework for end-user participants to suggest design ideas during design activities, both at design time and in future design iterations</td>
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</tbody>
</table>

As summarized in the table above, in the context of the existing meta-design research agenda, this study contributes an understanding of the customization dimension of a meta-design system. It begins to answer the question of – how do we define a meta-design system and how do we measure its quality? The laboratory study contributed an understanding of the levels of customization and the ratio between the levels. The quality dimension of a meta-design system may be difficult or impossible to measure, as it happens over time and space. The balance of
customization features, from fixed to display to functional, may be a better approach to describe and evaluate such systems. Additionally, these customization features evolve over time; they were seen to be different in the design of a new system versus that of an existing system.

This work has provided an understanding of the elements of current technology exemplifying meta-design and a means of understanding and characterizing the balance between elements supporting varying levels of end-user customization. This can serve both as a benchmark and a framework for building our understanding of the ideal meta-design system. These findings are also necessary to move meta-design from theory to practice and to ground our further research and discussions in the area. Additionally, these findings spark new research questions and potential further research work in this area, which will be discussed in greater detail in the future work section.

From a practical standpoint, however, the question is raised as to how these findings help contribute to meta-design practice in real-world contexts? As discussed earlier, the concept of meta-design is embedded in real-world dimensions such as time and space, that are not easily (or meaningfully) addressed in a laboratory context. The ipl2 design exercise and diary keeping study were intended to explore the meta-design inspired guidelines in a more naturalistic setting, as well as begin to answer questions that emerge during use, such as what motivates end-users to contribute to design. The findings in these portions of the study were promising; the meta-design inspired guidelines were well-understood and used by both end users and
designers engaged in co-design. The end users had a number of design ideas that emerged during their normal, daily use of the system. And the designers and end users came together multiple times to brainstorm future-focused design ideas for the system. This begins to stretch this process longitudinally across time and space. And this begins to move closer to a real-world context of use.

In general, it was observed that designers working together were most effective at generating future-focused design ideas. The end users were less adept at translating general guidelines to real design ideas, but they were able to utilize the guidelines. This suggests that, from a practical standpoint, the guidelines do have immediate value for skilled designers; the guidelines were shown to have an effect of focusing the design ideas on future customization opportunities. Although the guidelines were useful, they require future iteration and improvement. Future research efforts and research questions will determine these enhancements. However, for the present, these guidelines appear to be a useful start in the direction of applicable meta-design techniques.

In general, as will be discussed further in the limitations section, time and space can be exceedingly hard dimensions to tackle in an experimental setting. The overall findings indicated that the meta-design inspired guidelines can be usefully employed by design teams including end user participants, that these guidelines can be used in multiple sessions over time, and that these guidelines can shift design-time thought towards future customization in the hands of end users. These are all highly promising findings and indicate that this research work has potential to make a
contribution to both research and practice in the area of meta-design and design methods.

7.2 Limitations

There were several potential limitations to this study, largely involving the participants chosen and the number of data points collected. The participants in the laboratory portion of this study were design students who had taken courses in human-computer interaction at the iSchool at Drexel University, but these participants were not professional designers. While they were clearly well-versed in design techniques and methodology, the majority of these participants did not have extensive real-world experience conducting system design and evaluation. In an attempt to improve the study’s real-world validity, the ipl2 design exercise portion of the study moved closer to real-world practice by using designer and developer participants who had worked on a recent website redesign of the ipl2 (www.ipl2.org). This study could be strengthened and expanded in the future by using the meta-design inspired guidelines in ideation exercises with professional designers. This would also expand the number of participants used and the data points collected in this study, which may expose more statistically significant differences between the various treatment groups.

Similarly, in the diary keeping portion of the study only a small number of end user participants were able to be recruited and participate in the study. While these participants did provide useful data for analysis, a deeper exploration might have yielded a better understanding of end-user motivation to contribute to design
modifications in use. Also, these end-users, as study volunteers, were likely more interested in design than an average end user of a system might be and may not have been representative of the population as a whole.

The quality evaluation of the design ideas generated by participants was conducted by expert review; this may have been a limiting factor as well. The experts used in this assessment were senior faculty members and doctoral students in the field of human-computer interaction, with experience teaching and practicing design theory and methodology. As discussed previously, the proposed quality measures were all highly correlated with each other and with the general “overall quality” measure. The quality ratings were also highly correlated with the overall number of words written by participants, even for design ideas that were fundamentally the same and differing only in their verboseness. This may indicate that the scales chosen were not well-suited to measuring meta-design constructs. Having the participants take their designs beyond ideation, into sketching or prototyping, may also have given the raters more depth of understanding within which to make their quality assessment. Such a process would have had its own drawbacks in conducting the ratings, such as biases related to the participants’ visual design skills. And ultimately, the concept of assessing quality in meta-design systems is a difficult challenge. True meta-design systems must evolve over time and space and these are difficult dimensions across which to define and measure quality.

In the interest of research study scope, the laboratory study in experiment 1 was conducted as a 2x2 between subjects factorial design, with the main factors of use of
the meta-design inspired guidelines and end user participation. In the field of human-computer interaction, there are numerous design techniques and methodologies, some with an extensive history in the field and others only beginning to be adopted. It seems logical that one or more of these techniques might have been compared to the meta-design inspired guidelines and the control, which used no process for the design ideation. The goals of existing HCI methods are not oriented towards meta-design concerns and it is therefore difficult to attempt to make a comparison across multiple methods as such. Such a comparison would likely not yield meaningful or useful results in the context of meta-design; each of these existing methods intentionally focus designers on different attributes and potentials for the system which are not aligned with meta-design concerns. This is not to say that such methods do not have value in a future of meta-designers. A combination of existing and novel meta-design methods are likely most useful to future-focused design activities.

Finally, individual differences, as explored in the discussion chapter, likely played a role in several of the findings. Overall, it was observed that some participants were simply more willing to engage in extensive conversation and brainstorming around the guidelines then other participants. And this was typically regardless of their level of design experience. This effect of individual differences is well-known in both the cognitive psychology and human-computer interaction literature. Increasing the number of participants or diversifying to different participant groups (such as professional designers) may help to mitigate such an issue in the future. Many of these limitations, as discussed here, can be addressed by future work, as explored in the following section.
7.3 Future Work

These experiments provide a stepping stone on which to build an understanding of the value of future-focused design activity and how it might be extended across time, in a continuous and iterative fashion. Although continuous co-design remains a challenge to HCI, and to system building in general, this work may yield a better understanding of how to frame such design time thought. As mentioned earlier, in many organizations it is common design practice to at least superficially consider future possibilities. There are few techniques to help frame and shape such thought. Additionally, the participation of users is a common technique but there is little empirical work showing the value of user participation. Within the conceptual framework of meta-design, continuous participation and co-design activity is a key requirement. The research conducted in this series of experiments can help expand on these concepts and build the necessary empirical work validating the meta-design approach.

This series of experiments have primarily been oriented around design-time decision making by designers, with end-user participation. Moving forward, there is a need to connect the current findings with more dynamic, emergent contexts of use. Further exploration of continuous co-design necessitates building our understanding of the following key issues:

Co-design – users and designers must work together to create and evolve the system:
• How can design conversations between users and designers, framed by the meta-design inspired guidelines, be expanded across time and space?

• What is an appropriate balance between those playing the role of user and of designer at any given time?

Continuously evolving systems – in true meta-design systems, the system is never “completed”:

• What is an appropriate balance between the fixed and flexible elements of a meta-design system?

• How does this balance change over time?

• How does this balance differ between brand new systems and iterations on existing systems?

A Practical Understanding of Meta-design – more generally, as technology tools supporting end-user customization become common we must answer some fundamental questions about meta-design on a practical level:

• How do we define a successful meta-design system from both the technical and social perspective?

• How can we expand our understanding of what domains or contexts in which meta-design is an appropriate approach to system design?

The challenge of continuous co-design is one that is already beginning to be tackled in current real-world design and use. This topic is of the highest relevance to the field of human-computer interaction. Ultimately, our design methodologies must
evolve to support a world in which end users have the ability to play the role of consumer and/or designer, depending on context. These suggested future questions and directions begin to provide practical answers supporting the needs of meta-designers creating tools for future end-user crafters.

7.4 Moving Towards a Future of Design-in-Use

“Design may have its greatest impact when it's taken out of the hands of designers and put into the hands of everyone.” – Tim Brown (2009)

As discussed earlier, the vision of meta-design systems is far-reaching and highly complex. The evolution of existing technology has driven many common features today that move closer to the goal of meta-design (user-contributed content, personalization, macros, etc.). The cultural and social shifts in tandem are of equal importance. As Benkler (2006) notes, new means of production open new avenues for user contribution – “The networked environment makes possible a new modality of organizing production: radically decentralized, collaborative, and nonproprietary”. Sharing and evolving the systems we use on a daily basis has become the norm. Users and designers have shifting expectations of what should (or should not) be modifiable within a system and many of these expectations are still fixed at design time.

Looking forward to the immediate future, a great deal of our design will still happen at “design time”. In our exploration of meta-design inspired guidelines, we hope to contribute a way of design-time thinking to inspire ideas oriented around future system modification in the hands of end users. A few simple heuristics, such
as the series we have generated and begun to validate, can help designers and users communicate and brainstorm around future functional changes to the system.

None of the guidelines are novel concepts – rather, they seek to once again ground our relationship with technology in the same fundamental needs and motivations that drive all our design actions. As Christopher Alexander claims, every person has the inherent ability to design their environment; “each one of us has, somewhere in his heart, the dream to make a living world, a universe” (1979, p. 9). Alexander speaks from the architectural perspective, buildings and structures which we have spent our entire lives interacting with, improving and modifying as necessary, or through the actions of others. As our technological systems mature, this hands-on relationship with technology becomes more and more possible. We, as designers, can never anticipate all future changes or the unintended consequences of these changes once they are released into the complexity of real world situations.

As we have shown in our review of literature and previous work, these are ideas that have been struggled with for decades. As Bannon and Bødker would tell us, we are (way) past the human factors stage. Design is increasingly conducted in the hands of the people, the end users. Though many have discussed the themes and issues addressed by meta-design, we, as designers, are still left with little that is concrete. In this research study, we present a simple idea that works to focus design-time thought on future opportunities for end-user customization. Through the beginnings of this methodology and its future iterations we can assist designers and users to become meta-designers, focusing on inherent human needs and providing the tools to support
this evolution in use. The future of truly design-in-use technology is fast approaching, whether we as designers are ready for it or not.

In summary, this research study provides insight into how meta-design inspired guidelines can focus design time thought on future contexts of use, in which end-users control and modify their systems in use. The guidelines were shown to shift design ideas towards these possibilities in both a laboratory and real-world setting, indicating they are relevant to design in multiple contexts and on multiple problems. The guidelines are a simple, yet effective method of moving design work towards becoming meta-design work, for both the skilled and unskilled designers of the future.
LIST OF REFERENCES


Cooper, A. (1999). The Inmates are Running the Asylum. Indianapolis: SAMS.


Appendix A: Experiment 1 – Coding Scheme

- Establishing reputation/trust
  - Author-provided content
  - Dispute resolution form
  - Edition checking by professors
  - Professors upload textbook list
  - Rate sellers
  - Rate textbooks
  - Review traders
  - User ratings/feedback
  - Value assessment
  - Verifying listing accuracy

- Digital content
  - Convert e-books to common format
  - Handle copyright/DRM
  - How to sell digital content multiple times
  - Print hard copy of digital book
  - Trade e-books
  - Trade physical for digital content
  - Upload digital content
  - Download digital copy of purchased book

- Book metadata
  - Author biography
  - Availability
  - Compare contents between books
  - Compare editions
  - Condition/quality
  - Connect to Google books
  - Preview
  - Price comparison
  - Reviews
  - Search within
  - Tagging
  - Upload pictures
  - Price including shipping
  - Year

- Mobile access
  - Mobile app
  - Phone bar code scanning
  - RFID scanner for bookstore

- Course content
- Course bundling of all books
- Find current course content
- Upload assignment material
- Upload syllabi

- Layout & Design
  - Home page has simple search by title/ISBN
  - Interface like Google
  - Large GUI buttons
  - Tabs - trade/buy/browse/register/search
  - Similar design - Amazon
  - Similar design - Ebay
  - Specific home screen setup
  - Simple look and feel

- Localization
  - Location for hand-delivery
  - School-specific version
  - Sorting by proximity
  - Google shopping "search nearby"
  - Select location

- Accessing site
  - Call-in number
  - Free access

- Marketplace rules
  - Advertise prices on price aggregator sites
  - Barter for non-book items
  - Barter system
  - Book offers/counter-offers
  - Charge for advertising
  - Membership rules
  - Multiple item trades
  - Publisher store
  - Rental services
  - Return policy
  - Returns handling
  - Sell used books
  - Trade
  - Trade for site credit
  - Track borrowed/lent books

- Real-time communication
  - Chat between buyers and sellers
  - Discussions
  - Forums
  - Messaging
  - Means of communication between buyers/sellers

- Technical implementation
• Link shortener
• Link to feed reader
• Search engine optimization
• Secure payment
• Use as template to make personal trading websites
• Timed session
• Personalization
  • Connection to blackboard
  • Connection to school bookstore
  • Connection to school library
  • Connection to school reserves
  • Course-specific RSS feeds
  • Favorites
  • Language selection
  • Notifications of potential buyers
  • Personal history
  • Personal profiles
  • Saved ordering information
  • School avatar
  • User accounts
  • Wants list/wish list
  • Watching alerts
  • Customize, move or hide features
• Recommender system
  • Expert user booklists
  • Other students’ history
  • Recommendations based on purchases
  • Recommendations from peers
  • Recommendations from professors
  • Student created booklists
  • Recommendations
  • Most popular book recommendations
• Personal cataloging
  • Personal cataloging tool linking
• Finding
  • Browse textbooks
  • Groups/subject categories
  • List by course
  • List by course ID
  • List by professor
  • List by topic
  • List of school's required books per term
  • Search by course
  • Search by ISBN
  • Search by keywords
• Search by major
• Search by multiple options
• Search by school
• Search by textbook name
• Search by topic
• Sort by Condition
• Sort by price
• Tag content
• Tag course
• Tag people

• Social networking
  • Facebook marketplace
  • Friending
  • Shared login with social networks
  • Social network linking
  • Social network within site
  • Twitter feed

• Helping users
  • Dictionary
  • Live help
  • Help from peers
  • Help from professors
  • Q&A
  • Site feedback
  • Setup wizard for new users searching/selling

• Purchasing tools and options
  • Alternate sites
  • Create shipping labels
  • Delivery options
  • Order books
  • Package deals for multiple books
  • Payment by barter system
  • Payment by credit system
  • Payment by Google checkout
  • Payment by multi-book trade
  • Payment by Paypal
  • Payment by trade credit
  • Payment by virtual bank
  • Payment information
  • Payment options
  • Print shipping labels
  • Shipping arranged for sellers
  • Shipping options
  • Shopping cart
  • Track shipment
- UPS delivery
- Suggest price based on quantity available
- 1-click buying with stored information
## Appendix B: Experiment 3 – End-User Diaries

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>What are you doing on the ipl2 right now?</th>
<th>What is the problem or possible improvement?</th>
<th>Do you have any ideas or solutions to this problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/23, 7:30pm</td>
<td>Generally exploring the site, taking a look at areas where I have subject expertise</td>
<td>Not all resources are included in subcategories. Economics is not indexed at all. It’s inconsistent and makes it difficult to find resources on subject pages. Some resources are effectively hidden as a result.</td>
<td>Every area needs to be indexed/have subcategories, and there needs to be a simpler way to sort/see range of results.</td>
</tr>
<tr>
<td>2/27 10pm</td>
<td>Writing a scenario using the U.S. Presidents section</td>
<td>Search within the POTUS collection</td>
<td>Allow users to restrict their searches to particular areas of the site.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduce cross-referenced pages for topics within POTUS collection</td>
<td>Build new pages to meet this need.</td>
</tr>
<tr>
<td>3/3, 6:30 p.m.</td>
<td>Completing a heuristic evaluation using search and</td>
<td>No way to sort or filter search results</td>
<td>Allow users to sort and filter results by section of the site.</td>
</tr>
<tr>
<td>Date/Time</td>
<td>What are you doing on the ipl2 right now?</td>
<td>What is the problem or possible improvement?</td>
<td>Do you have any ideas or solutions to this problem?</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>March 5, 2011 3:30pm</td>
<td>Searching for information on American steel industry in newspapers.</td>
<td>No results are provided. Even when I broaden my search to “steel”, still no results. Farm in RSS feeds from the newspapers that the IPL has linked to and make those feeds searchable, or provide search results for relevant info.</td>
<td></td>
</tr>
<tr>
<td>March 5, 2011 3:30pm</td>
<td>Looking up a youth Jewish organization.</td>
<td>Can’t navigate to sibling categories within the organizations section of the IPL. For example, once you get to “Teen Home &gt; Clubs and Organizations &gt; Multicultural” the left navigation disappears. Keep sibling page navigation around in case what you are looking for in the selected category doesn’t end up being there. That way you can jump around to other categories.</td>
<td></td>
</tr>
<tr>
<td>March 5, 2011 3:45pm</td>
<td>Navigating to a Pittsburgh newspaper</td>
<td>Navigation does not remain consistent. Main newspaper section has accordion navigation, and then once you make a selection, it switches to left-pane navigation. Make navigation consistent. Pick one type and stick with it.</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Activity</td>
<td>Observation</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>March 6, 2011 10:25am</td>
<td>Browsing around the special collections section. Clicked on “Hurricane preparedness”</td>
<td>All of the other categories that I clicked on in the Special Collections page brought me to another IPL site with further resources. This is what I expected for the hurricane preparedness section, but it opened up a new tab and went to an outside website.</td>
<td>Make all categories consistent. Link this page to another “Further resources” page within the IPL about hurricane preparedness.</td>
</tr>
<tr>
<td>March 6, 2011 10:30am</td>
<td>Browsing around the Special Collections section, clicked on U.S. Presidents</td>
<td>None of the “Featured and Popular Collections” webpages, nor any of the main categories from the main page have breadcrumb navigation, whereas other parts of the site do.</td>
<td>Make consistent breadcrumb navigation across ALL pages of the IPL so as to give users a context of where they are in a page and to allow them to recover from navigation errors.</td>
</tr>
<tr>
<td>March 6, 2011 10:40am</td>
<td>Browsing “For Kids” section</td>
<td>Why is there a “Resources for parents and teachers” link on the “For Kids” page? Would a parent or teacher go to the “For Kids” section to get information for themselves?</td>
<td>Information Architecture mishap here, consider moving that link elsewhere or creating a separate “For Parents and Teachers” section.</td>
</tr>
<tr>
<td>March 6, 2011 11:00am</td>
<td>Navigating through “For Teens” section, looking for Jewish youth</td>
<td>Noticed categories don’t seem to be in any sort of specific order, whether alphabetical, related topic, tags. Same goes for sites listed in sub-categories.</td>
<td>At least alphabetize these listings, if there is no other method of organizing.</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Comment</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>March 10,</td>
<td>9:05pm</td>
<td>Navigating through “For Teens” section, looking for Jewish youth organization. Not all links to external websites are categorized where you think they would be. Ex: B'nai B'rith Youth Organization is filed under &quot;Religious&quot; when it could also be tagged under &quot;Multicultural&quot;.) Allow for a tagging system where a particular resource could have many tags, and thus categorized under many categories. Have a review of the Information Architecture of the IPL and maybe a card sorting exercise to determine where certain things belong.</td>
<td></td>
</tr>
<tr>
<td>March 10,</td>
<td>9:15pm</td>
<td>Curious about “Learning HTML” resource in the For Kids section because I am currently in a web development co-op. Last bullet under “Extra Stuff” doesn’t lead anywhere, no link to further resources. Include links to pages about how to create each of the things talked about in that line of text (“Backgrounds, bullets, images, and more”)</td>
<td></td>
</tr>
<tr>
<td>March 10,</td>
<td>9:15pm</td>
<td>Still on “Learning HTML” page. Comic Sans font is used everywhere. Just don’t. Please don’t ever use that font. Also, it does not prove to be consistent with the rest of the website. Pick a font and use it across all of the IPL for consistency.</td>
<td></td>
</tr>
<tr>
<td>March 13, 2011 1:00pm</td>
<td>Browsing research strategies in “For Teens &gt; A+ Writing Research Paper Guide &gt; Step by step &gt; Step 4.3 &gt; Organizing Information</td>
<td>Found many broken links in this area. Particularly, anything of the form: <a href="http://www.coun.uvic.ca/learn/program/hndouts/classX.html">http://www.coun.uvic.ca/learn/program/hndouts/classX.html</a> (substitute X for 1 through 5)</td>
<td>Employ a programmatic function to spider links on the IPL for anything that returns a 404 Error, page not found. Or have periodic reviews of all links on the site for any broken links.</td>
</tr>
</tbody>
</table>

Appendix C: Glossary of Terms

Co-Design

Co-design is an approach to system design in which end users are not simply passive receipts of a completed system; rather, end users are active contributors to the system’s design, working collaboratively with system designers. Co-design is inherently participatory, in that end user stakeholders must contribute to design activities.

Continuous, Participatory Co-Design

Continuous, participatory co-design represents a methodological approach to meta-design that can be realized within current design processes and technologies. In such an approach, design activities occur over the entire life of the system (i.e. continuously) and involve end-users and designers in participatory activities in which the system is evolved, or co-designed (see above), together. Both designers and end-users serve as active contributors to system design and evolution.

Customization

A key principle for the meta-design of socio-technical systems as described by Fischer & Hermann (Fischer & Hermann, 2011) is to provide building blocks for the eventual end users of the system to “freely combine, customize, and improve these components or ask others to do so”. Customization refers to the ability of the feature, or design idea describing a feature, to support end-user modification in use; this may include adding content, developing functionality, or otherwise shaping the system at use time.

Design

Design is a common human capacity to identify misfit and apply iterative corrections in order to change “existing situations into preferred ones” (Simon, 1996) in pursuit of some goal.

Big “D” Design

Design actions in which “extreme forms of originality” (Fasko, 2006) are expressed, often transforming domains.

Little “d” Design

Design actions which solve more commonplace small problems through “everyday creativity” (Fasko, 2006).
Design Time

Design time refers to the stage of design in which systems developers create environments and tools, either with or without the input of end-users. In traditional design processes, this process yields a completed system, but may not account for the emergent, unpredicted needs of end-users at use time (also see use time definition below).

Human Actors

Human actors are end-users who control the technologies used in their daily lives and participate in design-time activities. This view of end-users emerged during the 1990s, when technology moved into the home and human-computer methodologies began to take a broader view of interaction. Our current HCI methodologies (e.g. user-centered design) and theories are largely oriented towards this “human actors” relationship between technology, users, and use (Bannon, 1991).

Human Crafters

Human crafters are end-users that are empowered and willing to design their technological environments. Historically, many early acts of design were conducted by human crafters; end-users are again behaving as human crafters – controlling, designing, and developing not only their relationships with technology, but the very form and function of this technology.

Human Factors

When environments of use were constrained to the workplace, our early HCI methodologies could strive to match known work tasks with suitable interfaces; this human factors approach focused on the line between man and machine and the interfaces that afford interactions between the two (Bannon, 1991).

Meta-Design

Meta-design refers to the objectives, techniques and processes for creating socio-technical environments that empower end-users to contribute to the continuous development of their systems during use (Fischer, Giaccardi, Ye, Sutcliffe, & Mehandjiev, 2004)

Meta-Designer

Meta-designers create socio-technical environments that provide the tools for other people (consumers and designers) to express their creativity and shape the environment to fit their emergent needs. In addition to creating technological artifacts, meta-designers create the necessary conditions, both social and technical, to facilitate and encourage expansive participation in design (Fischer, 2003).
Meta-Design-Inspired Guidelines

A primary goal of meta-design is to facilitate end-user modification at use time (see above). To this end, the meta-design inspired guidelines are a technique that seeks to focus designers on possible future motivations of end-users and the necessary environmental tools that must be provided to empower end-users to shape their system in use. In this sense, the guidelines are meta-design inspired, and seek to contribute another practical technique to meta-design.

Participatory Design

User participation is the focal point of participatory design, which has its origins in union-driven projects in Scandinavia in the 1970s (e.g. Ehn & Kyng, 1987). Such an approach advocates for the inclusion of all stakeholders in design processes, to ensure the resulting product meets their needs. Participatory design methods may be a part of a user-centered design process (see below) with the goal of understanding the users’ tacit knowledge in the building of co-designed solutions, from workplace processes to technology tools. Participatory design has historically focused on bringing designers/developers and end users together at design time to envision future contexts of use.

Scenario-Buffered Design

A participatory process of design, proposed by the architect Stewart Brand, in which designers and other stakeholders (e.g. building occupants) first work together to identify the driving forces that will shape the future, then design adaptable buildings that can flexibility suit these possible divergent futures (Brand, 1994).

Tailorability

Tailorability is the ability of a system to automatically identify the user’s needs and adapt to them or to allow the user to modify the system to suit their preferences. System tailorability is a key requirement for systems that allow end users to design in use, as identified by Henderson and Kyng (Henderson & Kyng, 1991).

Underdesign

Instead of focusing on creating a completed system at design time, an underdesign approach seeks to design only the tools necessary for end-users to construct their environments during use. This allows for future modifications in the hands of end-users, as necessary to support future unpredictable contexts. Within the overall framework of meta-design, underdesign serves as a “defining activity aimed at creating design spaces for others” (Fischer, et al., 2004)
**Use Time**

Use time refers to the stage of design following design time, in which end-users employ the system to achieve their real-world goals. In this stage, end-users often have needs that were not predicted by system designers at design time. Within a meta-design approach, the system is underdesigned (see above) such that the end-users are provided with the tools to shape the system as needed to support these emergent needs.

**User-Centered Design (UCD)**

User-centered design (UCD) is an approach to design that focuses on the end-users of the system through all phases of design and development. The UCD model typically encompasses the analysis, design, and evaluation of a system; all phases are conducted iteratively and with the goal of building an understanding of end-user needs throughout all activities. UCD methods are diverse and tailored to the phase of design (e.g. personas in the analysis phase, prototyping in the design phase, and usability testing in the evaluation phase) (Rogers, Sharp & Preece, 2011).
VITA

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