Sitemaps, Storyboards, and Specifications: A Sketch of Web Site Design Practice as Manifested Through Artifacts

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ABSTRACT
Through a study of web site design practice, we observed that web site designers employ multiple representations of web sites as they progress through the design process, and that these representations allow them to focus on different aspects of the design. Designers also employ multiple tools during the course of a design project, including graphic design, web development, presentation, and word processing software, as well as pen and paper. Sketching on paper is especially important during the design exploration phase of a design project, when designers wish to explore many design possibilities quickly without focusing on low-level details. Web site design tools intended to support the early phases of the design process should employ informal interaction techniques and should integrate well with other applications that designers use regularly.

Keywords
Ethnography, Interaction Design, Web Site Design, Information Architecture, User Interface Design, Work Analysis, User Studies, Informal Interfaces.

INTRODUCTION
We undertook a study to identify current practices in the field of web design. The goal of this study was to illuminate issues that will guide the design of informal tools for supporting web site design. By "informal" we mean tools whose user interfaces are designed to support natural, ambiguous forms of human-computer interaction [11]. Examples of interaction modes that informal interfaces support include speaking, writing, gesturing, and sketching.

We are interested in the exploration of informal interfaces in general, and in our research group we have developed informal applications to support graphical user interface design [15] and group note taking [5, 14]. We know that designers in general employ ambiguous means of expression and communication (such as sketching on paper) when they are exploring design ideas [4, 10, 22]. Since web design is an emerging field, the tools to support it are not yet mature. We believe that there is a real opportunity for improving the state of the art.

In the remainder of this paper we present related work, describe the study that was conducted, present the picture of web design that was observed through the study, and discuss the implications of our study towards future web design tools.

RELATED WORK
Several work practice studies have appeared in the literature that are especially relevant to our study of web site designers. Sumner and Stolze's study of speech application designers [21] and Bellotti and Rogers' study of editorial staff at several publishing companies [1] showed that designers and editors use multiple intermediate representations of products during their creation, some of them similar to the representations found in this study.

A certain amount can be learned about web design practice by reading the growing body of literature that covers it [8, 17-19]. Unfortunately, much of this literature is prescriptive rather than descriptive in nature, and may not accurately reflect what designers are actually doing in the field. To learn what designers do, there is no substitute for direct contact. We elected to conduct a first-hand investigation into web design practice through field visits and interviews with professional designers. Our approach was inspired by the methods proposed in, for example, [3, 12].

DESCRIPTION OF STUDY
We interviewed eleven designers involved in the web site design process. Ten of these designers were at five different companies and one was a freelance designer. We also collected and studied many artifacts of the design process, including sketches, prototypes, written documents, presentations, finished web sites, and several other types of artifacts, some of which will be discussed later. All interviews were conducted in the designers' offices, which facilitated the observation of artifacts and allowed us to observe their working environments.

Years of experience	# of participants
Less than 5 years	7
Between 5 and 10	3
More than 20	1

Table 1a: Designers' Professional Experience

Background	# of participants
Graphic design	8
Computer Science	2
Cognitive Science & Library Science	1

Table 1b: Designers' Professional Background

Responsibility	# of participants
Graphic design	4
UI Design/Information Architecture	3
Hybrid	4

Table 1c: Designers' Current Responsibilities

Who Was Interviewed

Four of the five companies we observed were design firms that are typically contracted by outside clients to design sites or interactive products. The fifth company was a large Internet directory and search engine (i.e., a "portal").

The designers represented a range of professional design experience levels (see Table 1a). All of the designers with more than five years of experience had been involved in designing user interfaces for software applications before getting involved in web site design, and one of them had been involved in print design as well.

Most of the designers interviewed had backgrounds in graphic design in terms of education and experience (see Table 1b).

In terms of the designers' current responsibilities, four were focused almost exclusively on graphic design, three were focused exclusively on user interface design/information architecture, and four had responsibilities that were general enough to incorporate aspects of both kinds of design (see Table 1c). The meanings of the terms "graphic design," "user interface design," and "information architecture" are discussed in the next section. None of the designers were involved in programming or development of the final, production versions of the sites they designed.

What Was Asked

Each participant was asked to choose a recently completed or nearly completed project, and to walk the interviewer through the entire project, explaining what happened at each phase. The designer was asked to show examples of documents that he or she produced during each phase and explain the meaning of the document with respect to the process as a whole. At the end of some of the interviews, the designer was asked to give copies of the documents discussed during the interview to the interviewer for the interviewer's reference. In this way, examples of design process artifacts were collected from four designers.

Examples of projects discussed include corporate identity and information sites, a state tourism site, a site for a major municipal aquarium, an online clothing catalogue, a university site, an online software tutorial, and sub-sites of a large Internet portal.

SPECIALIZATION WITHIN WEB DESIGN

Designers were careful to use specific terms to refer to different areas of concern within the web design space. The term *information design* was used to refer to the problem of identifying groups of related content and structuring information into a coherent whole. A closely related area, *navigation design*, refers to the design of methods of finding one's way around the information structure. *Graphic design* (also called *visual design*) refers to the visual communication of information using elements such as color, images, typography, and layout. Whereas information and navigation design focus on the entire web site and the relationship between large-scale elements (such as pages) within the site, graphic design focuses primarily on the presentation of individual elements.

Information architecture is an emerging specialty within web site design that refers primarily to the combination of information design and navigation design.

The term *user interface design*, when applied in the web domain, refers primarily to the design of navigation systems, with some overlap into information design and graphic design. In addition, an individual specializing in user interface design often has responsibilities extending to testing and verification of the overall usability of the site.

Figure 1 represents the relationships among the different areas of design. There are many areas of overlap between different types of design. For example, the design of an individual page must take into consideration the information that is to be presented on the page, its relation to other information found elsewhere on the site, the support for navigation to other areas of the site, and the visual presentation of information on the page.

In three of the five companies studied, there were specialists who focused on particular areas of design. One of these companies focused exclusively on information architecture and user interface design and subcontracted graphic design. Two companies had specialists designated as "Information Architect/User Interface Designer" (in both cases a hybrid title was used) and specialists designated as "graphic designer," though these latter individuals were simply referred to as "designers." The two remaining companies did not distinguish among the different types of design, but rather the same individuals would practice different types of design at different points during the design process. The independent consultant primarily focused on graphic design.

In almost all cases, information and navigation design were done *before* graphic design. At the web portal, the graphic designers preferred to have the information structure worked out before the project reached their desks. In the firms where a single designer would focus on different types of design at different phases of the process, he or she would switch to graphic design only after working out the information structure and obtaining approval from the client. One firm tended to work on graphic design ideas before (or sometimes in place of) working on information and navigation design. This discrepancy seems to have arisen from the firm's background in print advertising and their emphasis on novel, entertainment-oriented sites.

THE STORY OF A DESIGN: A SOFTWARE TUTORIAL

Before presenting a general description of the design process, it will be helpful to ground the discussion with a look at a particular design project. The project described was a tutorial for a suite of software CAD tools. The tutorial was designed for deployment on intranets of companies using the client's CAD tools, remote access via the Internet, and distribution on CD-ROM.

This project was one of the shorter projects discussed in the interviews, although the overall process and the artifacts produced are representative of the projects described in other interviews. The durations of each phase of the design, however, should be taken with a grain of salt, as there was a great deal of variation among projects. The *relative* amounts of time dedicated to each phase is consistent with projects described by the other designers.

The design team for this project consisted primarily of a designer, a creative project lead, and an account manager. The designer carried out most of the design work, in close consultation with the creative lead and with other designers in the firm. Other team members were concerned with other aspects such as client contact, budget, and schedule.

During the first two weeks of the project, the designer immersed himself in the background information for the project. This consisted mostly of reviewing the previous version of the tutorial (as this was a complete redesign of an existing product) and engaging in extensive discussions with the client to understand the content of the tutorial and get feedback about what was desired for the new version. During this time he also sketched some ideas on paper, including representations of the structure and navigation of the previous version of the product, and new structures representing ideas about how to improve certain aspects. At the end of the two weeks, a written "Needs Analysis" document, detailing project goals, schedule, and general design directions was delivered to the client.

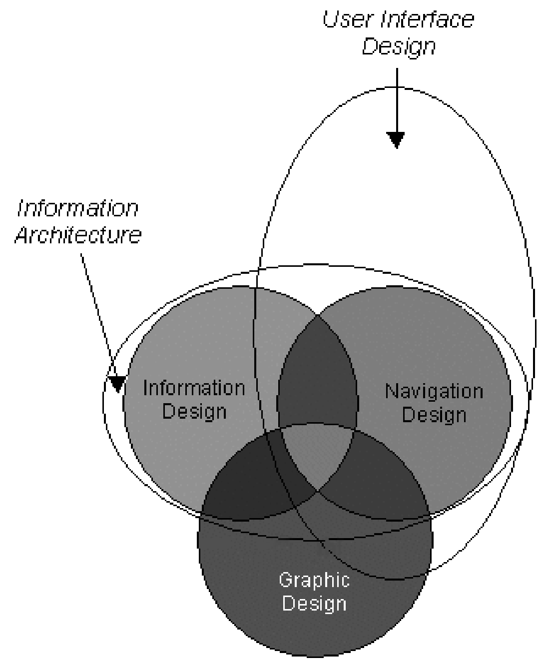

Figure 1: Different dimensions of web design

A meeting with the client was scheduled for the week following the delivery of the Needs Analysis at which initial ideas for the redesigned product were to be presented. The designer spent the week generating "Initial Design Variations," which focused on the high-level structure of the tutorial and the basic means of navigating the structure. He first made about twenty sketches on paper representing the overall structure (see Figure 2), individual pages (see Figure 3), and specific interaction sequences (see Figure 5). In order to create something "presentable" for the client, he then created two variations of the site structure and navigation using Adobe Illustrator, which he showed to the client as a large-format color printout. He also created a walkthrough of the structures. The walkthrough was created as a sequential presentation in Macromedia Director consisting of images produced in Illustrator.

The images presented in the walkthrough were representations of individual pages in the tutorial. These representations were devoid of images and icons, used a simple color scheme consisting of three colors (blue, green, and black), and contained almost no typographic variation. The colors used for these representations were not intended to show the colors that the final pages would be, but instead were used to differentiate different types of content. The designer said he chose blue and green for these initial images simply "because blue is different from green." He intended to show that different regions of certain pages would be colored differently from each other in order to distinguish them, but he did not intend to propose what the final colors would be. Similarly, the bland typography and lack of images were not intended to represent decisions about the final product, but were used intentionally to keep

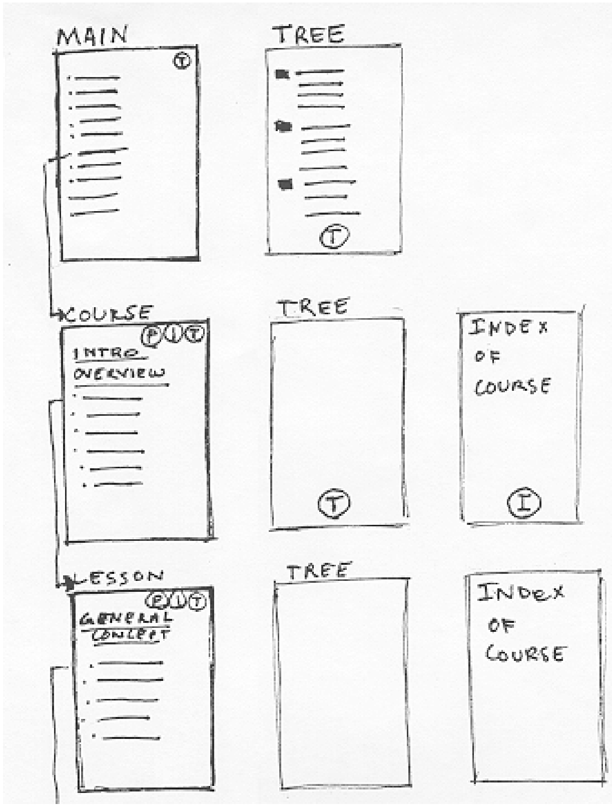

Figure 2: A portion of the sketch of the overall structure of the CAD software tutorial described in this section.

the focus on the "mental model" of the tutorial, i.e., the overall structure and the means of navigating that structure.

After the presentation of the initial design variations, the designer had a week to prepare the first round of "Visual Design Variations." Whereas the initial design variations were intentionally devoid of graphic details, the visual variations were intended to address these details. In particular, high-fidelity mock-ups of the home page and one second level page were created (Figures not available but see Figure 7 for an example of a mock-up). These mock-ups contained images, icons, rich typography, and sophisticated color schemes, and these details of the visual presentation were meant to be taken literally.

In order to produce the visual variations, the designer made a few "very quick" sketches on paper, and then created mockups using the "Paint" window of Director. In addition, three other designers within the firm were asked to create mockups in order to give the client a wide range of options from which to choose. All of the mockups were based on the initial design variations. As was done the previous week, a Director presentation was made to the client, this time showing electronic mockups of five different design ideas. The client selected two designs for further development and a meeting was set for the following week.

The designer spent the next week refining and developing the selected designs using Director. The next presentation included not only the refined home pages and second level pages, but several other "content pages" as well. The goal of this presentation was for the client to select a single design for development into a prototype. It turned out that the client liked aspects of both designs, so the two were merged and the hybrid design was selected for further development.

At this point, the client announced that they wanted a prototype produced as soon as possible for an upcoming trade show in three weeks time. This shortened the amount of time that the designer could spend refining and developing the visual design ideas and forced an early transition into "production mode." He worked on the mockups for a little bit longer before beginning to code the prototype in HTML. He said that his normal practice is to flesh out the mock-ups as completely as possible before starting to code since he likes to "in PhotoShop make this as complete as [he] can and then switch my mind from visual design into coding." Once he begins coding, he does not work on the mock-ups anymore.

For the two weeks while working on the prototype, he used PhotoShop to work on images and icons and Bare Bones Software's BBEdit to write the HTML. He also used Netscape Navigator to preview the prototype.

According to the designer, the development of a prototype is usually followed by the writing of guidelines or a specification to accompany and specify the prototype. Such a document would be handed off to whoever would develop the design into a working product. At the time of the interview, however, the guidelines had not been written. The client had not determined whether they wished to develop the prototype into a product, or whether the prototype was to be used to convince the client organization's management to pursue a more serious redesign. Without knowing the ultimate fate of the design, neither the client nor the design firm thought it worthwhile to devote time and effort to producing guidelines.

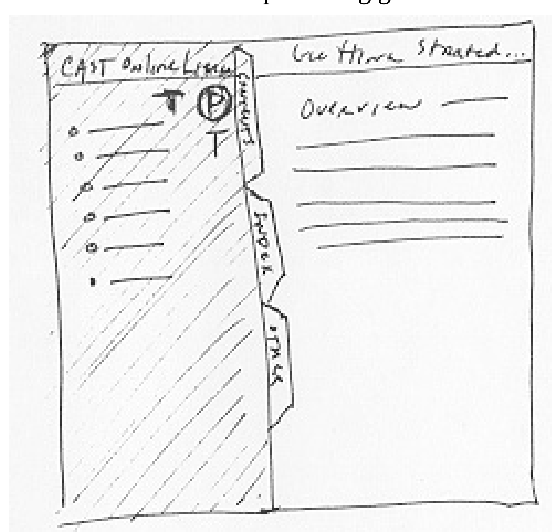

Figure 3: A sketch of one page within the tutorial.

THE DESIGN PROCESS

As was seen in the preceding story, designers follow a process of iterative refinement that moves the design from high-level and general to increasingly specific and detailed. Depending on the designer, and the organization in which the designer works, the process that is followed may be less or more explicit. In the types of design firms studied in this investigation, the process tends to be explicit, largely because it directly structures the interaction between the designers within the firm and clients and other stakeholders.

Each phase of the design process is usually punctuated by a presentation to the client at which the designers obtain approval from the client (often called *sign-off*) about the work that was performed during that phase. The explicit design process, which is often published on the firm's web site or made available to clients in other published forms, is also used to educate new and potential clients about how the firm operates and what they can expect. Only the web portal and the free-lance designer did not have explicit, published processes though the designers at the web portal claimed that they were in the process of developing one internally.

Presented here is a generalized design process, derived from the processes described by the designers interviewed and refined in subsequent conversations with them and with other designers. This process has four phases: *discovery*, *design exploration*, *design refinement*, and *production*. The number of phases is consistent with the three to five phases found in a short survey of published design processes from several other firms [6, 7, 20, 23].

Discovery

The purpose of the discovery phase is to determine and clarify the scope of the project, the desires of the client, and the characteristics and/or needs of the intended users. If the project is a revision or redesign of an existing site or product, the designers will carefully review and evaluate the existing version. It is common to perform a *competitive analysis* during this phase, which involves reviewing and evaluating competitors' products for common features and opportunities for improvement and differentiation. Other techniques that might be applied at this phase include interviewing or corresponding with the client to clarify aspects of what is expected, and various techniques to discover the needs of the users such as interviewing, observing, testing, or surveying.

Design Exploration

During the design exploration phase, possible solutions to the problems identified in the discovery phase are generated and explored. Information design, navigation design, and rough graphic design are often performed during this phase. Multiple rough design ideas and variations are generated. Initial designs generated at this point may or may not reflect ideas about color, imagery, and typography. Often they do not. They often *do* reflect ideas about site structure and navigation, though this is not universal. Normally the goal of this phase is to quickly produce several designs and present them to the client who is expected to select one for further development.

Design Refinement

After a design idea has been selected from the variations presented in the design exploration phase, the designers develop the selected idea further. During this phase the design is iteratively refined and detailed. Such aspects as the precise typeface of labels and body text, the exact sizes and appearances of images, and color schemes and palettes are determined. For most sites it is not necessary to design every single page of the site, since the site will have been broken down into classes of pages (for example: home page, second-level pages, pages for specific types of content), each of which can be represented by an example or *template*. A fully detailed example of each type of page is usually considered sufficient to represent the design.

Production

When the design has reached a satisfactory level of detail, or when the deadlines and budget dictate that design should end and implementation begin, designers prepare the design for hand-off to the people who will implement the site. *Production* refers to the creation of whatever artifact or set of artifacts will be delivered to the client (or to the software development team) to embody and represent the design. Such artifacts may include interactive prototypes, written descriptions, guidelines, and specifications.

PRODUCTS OF THE DESIGN PROCESS

Throughout the design process, the web site being designed is represented as a set of intermediate artifacts, such as site maps, mockups, and prototypes, that help facilitate communication among the various individuals involved in the design project. Artifacts may support communication among team members, between designers and clients or other stakeholders outside the design team, between designers and implementers, or simply between the designer and herself. Often an individual artifact will support multiple dimensions of communication.

Site Maps

A *site map* is a diagram showing the structure of a site (see Figure 4). It is used primarily to reflect an understanding of the structure of the site as it is being built and the boundaries of the information that is to be contained in the site. In many cases, site maps are only used internally by the design team to organize work and obtain consensus on the goals of the project. In some cases, though, site maps are cleaned up and shared with clients. A site map might, for example, be printed out in a large color format to be shown to the client. Sometimes, site maps are published on the release version of the web site, though these are often substantially different from the site maps used internally.

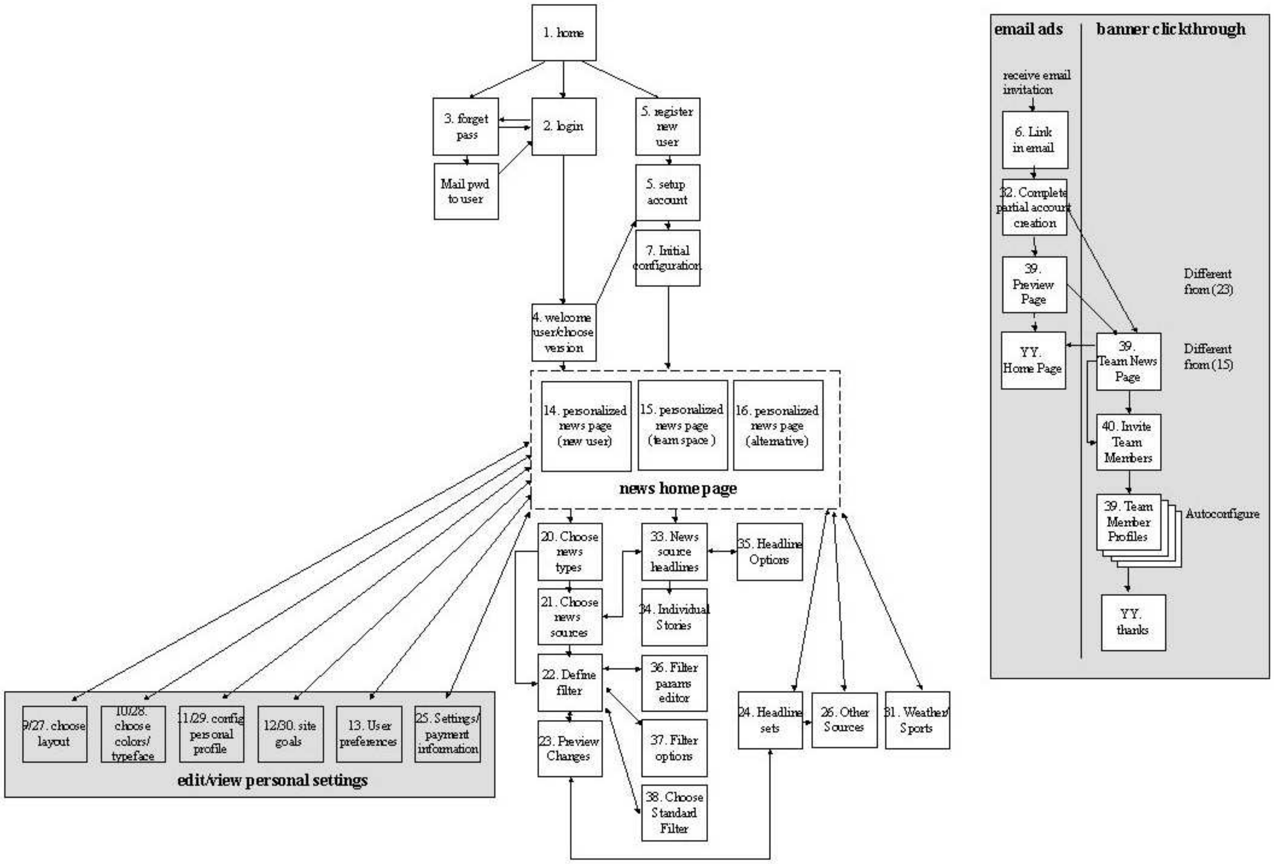

Figure 4: Site maps are high-level visualizations of site structure in which web pages or entire subsections of the site are represented by textual labels. This site map is for a hypothetical news web site.

Site maps often evolve throughout the entire life of the project, being updated constantly to reflect new understandings of the site structure. Early in the design process, site maps will reflect the site's structure very broadly and as time progresses, they will be revised to become increasingly detailed. In some cases, where site maps are used more extensively, they will evolve until they reflect every single page in the site. They can then be used to support project management, content management, and the generation of specifications. Site maps are the primary artifact of information design, and in organizations that maintain information design specialists, the site map will be generated and updated by that specialist.

Site maps usually consist of labeled blocks and lines as in Figure 4, with some additional features to indicate certain kinds of groupings. The blocks represent individual pages and contain brief descriptions of the contents of the page, often only a short label. The lines and arrows represent navigational paths between pages. Often just the "primary" navigational paths are reflected in the site map. For example, even though it is common that users are able to reach the home page of a site from any page on the site, this fact is not reflected on a site map such as the one in Figure 4 – it is just assumed.

Storyboards

A storyboard is a representation of a particular interaction sequence. It is accompanied, either explicitly or implicitly by a story or scenario about the task the user would be trying to accomplish via the particular sequence depicted. Storyboards reflect limited detail about the contents of each page in the sequence and only the navigation links required to accomplish the task are represented. For example, the storyboard shown in Figure 5 shows an interaction sequence that a user might execute in order to access information within a tutorial system. It shows what would happen if a user started at the main page, clicked "Begin Tutorial," then clicked "Courses," and then clicked "Modeling." One other possible sequence is shown: when the user clicks "Cast Contents" she will be taken to the "Main Menu" page. It is clear that there are links on several of the pages depicted that would lead to other pages, but those interactions are not shown.

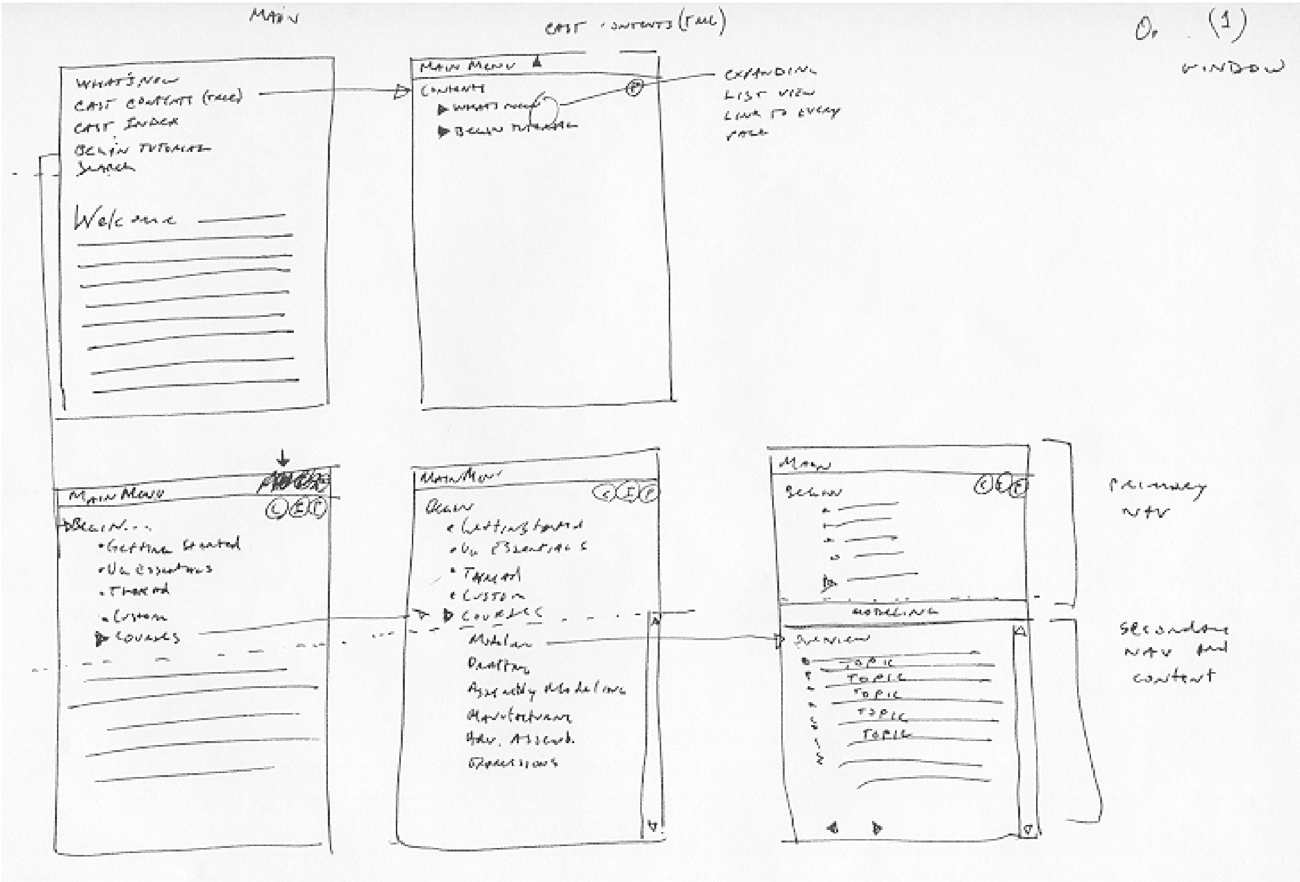

Figure 5: Storyboards represent sequences of interactions that a user would carry out in order to accomplish a task. This storyboard shows how a user would interact with a tutorial system to find information on a specific topic.

Like site maps, storyboards are primarily used within design teams to communicate ideas about site structure and navigation, and are not used to communicate with people outside the team, i.e., clients. The idea of presenting a scenario to a client is quite common, only it is usually not done using storyboards. Rather, designers prefer the *walkthrough*, which, like a storyboard, is accompanied by a story about what the user is doing and perhaps why. Whereas a storyboard is a document showing multiple pages at once and the transitions between them, a walkthrough is a mediated, sequential presentation of screens narrated by the designer with an explanation of what the user is doing on each screen. A storyboard might well be used to design a walkthrough.

Schematics

Schematics are representations of the content that should appear on a particular page. They are usually devoid of images, though they may indicate with a label where an image should be placed. While schematics are not meant to show how color, typography, and graphics will be used on the page, they may themselves use simple color (often they are monochrome or grayscale), typography, and graphics to indicate other things about the page. For example, simple typographic variations may be used to show that a particular label is supposed to be larger and bolder than other labels on the page. Colors and lines may be used to separate regions of a page from each other and indicate that those regions should be made visually distinct from one another when the graphic design for page is done. Schematics often mix actual page contents with annotations indicating the type of content that should appear in a particular region (see Figure 6).

Even though schematics focus on an individual page, they fall into the domain of information and navigation design rather than graphic design. All of the information design specialists created schematics as part of their work, whereas none of the graphic design specialists did. This is because schematics represent the information organization on a given page and the elements that support navigation that must be included on the page (e.g., links to other pages, navigation bars, feedback about the page's location within the site). In each case where specialization among designers was observed, schematics were used as a means of communication between the information architect and the graphic designer: the information architect would specify the page contents using a schematic and the graphic designer would determine how to present the contents in a clear and visually appealing manner.

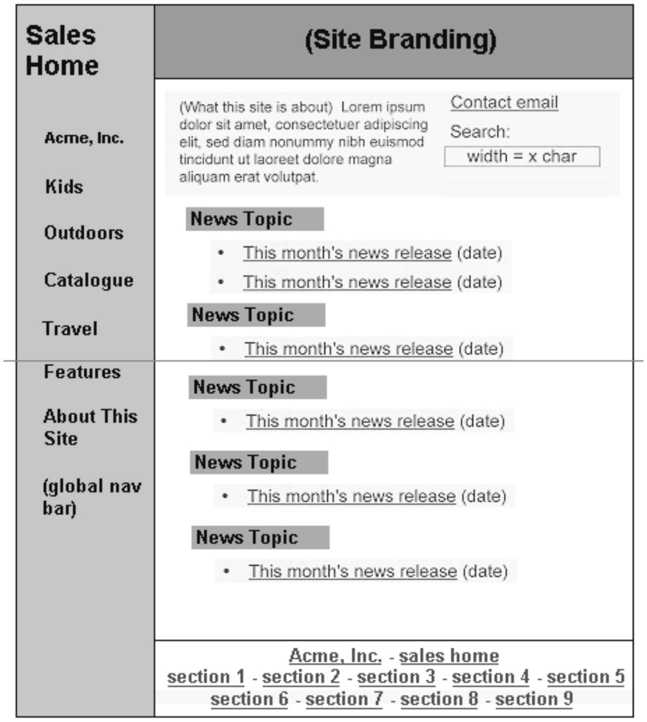

Figure 6: Schematics show the types of information and the information groupings on an individual page.

Designers in the organizations where specialization was not observed regularly produced schematics before working out the graphic design. Electronically produced page schematics are sometimes shown to clients during the early phases of design because they do not look like finished web pages. They can be made to look aesthetically pleasing and professional without appearing "finished," so they are appropriate for client presentations during early design. Presenting too polished a representation encourages clients to focus on irrelevant details such as fonts, colors, and images when it is often desirable at this point to get feedback on the structure and organization of information [22]. However, presenting too rough a representation can seem unprofessional and unimpressive. For design firms working with new clients, it is often important that they make a positive impression early in the design process to reinforce that the client made a good decision in hiring the firm. Early presentations must strike a delicate balance between keeping the focus on basic, structural issues and making a good impression. Schematics were regarded by several of the designers interviewed as a good way to balance these demands.

Mock-ups

A *mock-up* is, according to Webster's Dictionary, "a full-sized structural model built accurately to scale chiefly for study, testing, or display." In the web design domain, a mock-up is a high-fidelity representation of a web page that shows exactly what the page is supposed to look like. They are usually produced using a graphics application like PhotoShop and are not interactive.

Unlike schematics, the graphic design of a mock-up is meant to be taken literally. The mock-up shown in Figure 7 is a literal representation of a site's home page.

In some cases, mock-ups are the final deliverable of a design project, perhaps accompanied by written guidelines or specifications.

Prototypes

While the term *prototype* could refer to anything that serves to represent the system as a whole, and therefore is occasionally used to refer to a site map, a set of schematics, or a set of mock-ups, it is most often used to refer to an *interactive prototype*. Interactive prototypes are usually done in HTML or Macromedia Director, and allow the designer to demonstrate how the user will interact with the finished site. Prototypes are usually produced late in the design process (i.e., during the production phase).

Specifications and Guidelines

Specifications are detailed documents that attempt to describe exhaustively and precisely the intent of the design. They usually accompany some kind of a prototype and refer to it explicitly. The intended audience for a specification is the developers who will implement the site. The specification tries to instruct the developers about how to extrapolate from the prototype to the finished product.

Guidelines are similar to specifications, though the term "guideline" implies something less rigid and detailed than a "specification". Whereas a specification can be thought of as a set of exact instructions about how to build the site, guidelines are more like suggestions. Guidelines do not have to be as comprehensive, and they can leave more details to the discretion of the developers.

Figure 7: A mockup. Since mockups are high-fidelity representations of web pages, they are sometimes indistinguishable from the real thing.

Although some designers use the two terms interchangeably, for at least one firm studied the distinction between a specification and a guideline was considered extremely important. The principal of this firm said that there is a factor of ten difference in terms of production effort and cost between a specification and a guideline.

Several designers expressed a preference for *interactive specifications*, which integrate the specifications with the prototype. The precise form of the interactive specifications vary from firm to firm and from project to project, but generally they provide a way of accessing the specification information about a particular element of the site from the *element itself*, as it appears in the prototype.

Presentations

Especially in the design firms, presentations to the client were regarded by the designers as a significant part of the design process. Since interactions with the client may be limited and somewhat formal, presentations are often the only means available for designers to convey ideas about the design to the client. Designers at all four design firms described the process of creating client presentations as "a design process in itself." One of these firms has a "theater" for hosting client presentations that is a fancy meeting room that looks like an old movie theater. The purpose of the room is to impress clients and increase the likelihood that they will react favorably to the designers' presentations. Another designer had worked with an outside contractor for three weeks nearly full time to produce a presentation that was to describe the results of the discovery phase to the client.

Presentations often require strategic planning in order to evoke the desired response from the client. One designer described some of the complexity of creating a presentation early in the design process. The design team truly wants the client's feedback, and at the same time wants the client's approval. It is particularly important at this early phase of the process that the client is not misled into thinking that the site is nearly finished, so it is desirable to make the images presented appear somewhat rough. Similarly, it is not useful to get feedback about irrelevant details that are not appropriate to the early state of the design, such as the fonts used or the background color. On the other hand, the client may be unfamiliar with the designer's work, and may have high expectations, so it is desirable to make a good impression with a polished design that shows off the designer's strengths. These considerations are often in conflict and need to be carefully balanced when creating a presentation.

At all four design firms, presentations tended to punctuate phases of the process, especially in the early going. Later in the process, a higher comfort level could be achieved that would allow feedback and approval to be sought in less formal ways. For example, during later stages of the process some designers would post work to an extranet and allow the client to review it directly. Early on, however, presentations are frequent and tend to drive much of the designers' day-to-day work.

In terms of content, presentations may consist of any of the artifacts described in this section. Electronic mock-ups are the most common elements included, but site maps and page schematics are sometimes included as well.

Written Documents

In addition to specifications and guidelines, many other written documents appear throughout the process. A great deal of information regarding work progress, requests for additional work, and requests for feedback, to name only a few of many types of information, is transmitted through email. Additionally, several formal documents are often produced during the process, including reports on usability studies, reports on the results of the discovery phase, initial concept ideas (referred to at one company as the "creative brief"), market surveys, work schedules and contracts. It is hard to generalize about the types of things that appear in written documents, but suffice it to say that quite a bit of written material is generated. Some designers (especially the ones who called themselves "user interface designers") reported that Microsoft Word is the tool that they use more frequently than any other single tool.

PEN, PAPER, AND OTHER TOOLS

Almost all of the designers did at least some sketching on paper, though not necessarily consistently or to the same degree for every project. When sketching did occur, it would take place early in the process, generally during the design exploration phase, and was employed for information/navigation design as well as graphic design. Examples of sketches done in support of information and navigation design can be seen in Figures 2, 3, and 5. At some point the sketches would be converted into electronic form by recreating them from scratch using a tool such as Illustrator or PhotoShop. In almost all cases, once the designer had converted his or her sketches into an electronic format, paper would be abandoned.

Sketching on Paper

In keeping with our interest in informal modes of expression and communication, we paid special attention to ways that designers currently use sketching. Several designers indicated surprise that we wanted to see their sketches, and were even mildly reluctant to show them. The presentation of the sketches was accompanied by a series of apologies for their "poor quality," and disclaimers about how they were "really rough." Some designers seemed to be somewhat ashamed of their sketches, or perhaps they had misgivings about showing them to a relative stranger. According to several designers, anything presented to the client must look "professional," which means at a minimum a color printout or photocopy of a high-resolution mock up, and usually it means a mockup presented on a computer.

Several designers reported that they "used to sketch more." While it wasn't clear exactly what was behind this perceived reduction in sketching, one designer said that he began working with Illustrator and PhotoShop earlier and earlier in projects because he knew he would have to produce something to present to the client very early on. Knowing this, it was much easier to work in an electronic medium from the start. Several other designers agreed that early deadlines drove them to switch from paper to electronic media earlier in the project than they might have liked.

Another designer reported that she switched to working with computer-based tools when she thought she would be making a incremental variations to a single general idea. She said:

> *The beginning of each step I'll do on paper. As soon as I feel like I'm going to be starting any design revisions, then I'll move to [an electronic tool]… because it's easier to make changes to these things … I take the old thing and I move some boxes around and I save it again, and then I'm done.*

Some other uses of paper were observed besides personal sketching to work out ideas. Several designers reported using paper and pencil when meeting with other designers. Spontaneous ideas and revisions were captured on paper in these settings. Paper was generally preferred to whiteboards because of its portability: after the meeting one can easily take it with them back to the desk. Designers would also give printouts of electronic sketches to colleagues for comments and they would be returned to them with handwritten annotations (see Figure 8).

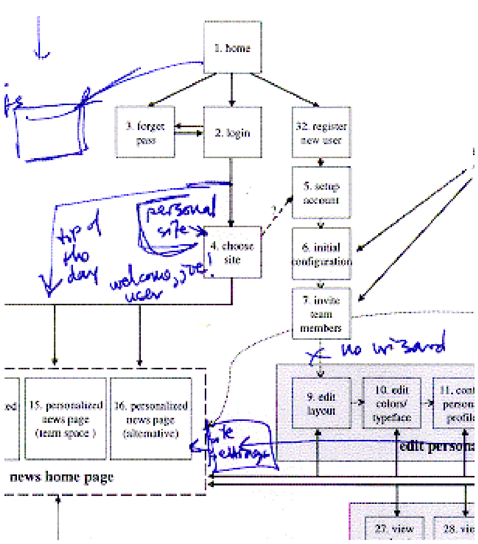

Figure 8: Another use for paper. Documents are printed, given to other team members, and annotated.

Two of the companies employed paper in a way different from sketching during the discovery and design exploration phases. In a process similar to the "Affinity Diagramming" technique described in [2] for organizing data collected from users, designers would collect ideas about what should be in the site onto post-it notes, and arrange them on the wall into categories. This technique amounted to a form of collaborative sketching to determine the site structure. At one of the companies that used this technique, other types of paper artifacts were also attached to the wall, such as annotated print outs of competitors' web pages. In these cases, it seemed that paper was exploited primarily for its portability and low cost. It is relatively easy to fill a room with pieces of paper and move them around to suggest different associations. The use of large surfaces, such as walls, allows a large number of complex associations to be represented at the same time.

Computer-Based Tools

The story of the designer working on the CAD tutorial illustrated the fact that designers use a wide variety of tools during the course of a project. His pattern of use was somewhat common, especially among the individuals with graphic design backgrounds. These designers relied heavily on some combination of PhotoShop, Illustrator, and Director for most of their work.

The user interface designers on the other hand did not use the same set of tools. One of the UI designers did not use any graphics programs at all: her diagrams were all on paper and most of her computer-based work involved writing reports using a word processor. Another UI designer made heavy use of Visio for making diagrams. She also used paper sketches to some extent and did a lot of word processing.

All of the designers, especially the more experienced designers, tended to be heavily invested in the tools they used. They admitted to using their preferred tools for tasks that might have been more easily accomplished with another tool. One designer did all of her diagrams, including site maps and schematics, using Microsoft Word's drawing utilities. Another designer said he used Director's paint function for all his graphics needs, even though he knew that PhotoShop would be better for some of the things he did. He simply did not have time to learn a new program. Similarly, the UI designer who used Visio for diagramming also used Visio for making page schematics, which she acknowledged might be easier to make, or at least more attractive, if they were made using a program with more graphics capability. Again, the potential gain from using a new program did not outweigh the inconvenience of having to learn it.

IMPLICATIONS FOR WEB DESIGN TOOLS

The motivation for this study was to guide the design of tools to support web design. We conclude by looking at the implications of this study for the design of such tools.

We found support for our hypothesis that an informal interface would be useful to designers. Since all of the designers sketch at least some of the time, and some designers sketch quite a lot, we believe that a sketch-based web design tool would fit naturally into many designers' work practices. Many designers reported that they were converting to electronic media earlier in the design process than they had in the past. A tool that provides some of the advantages of an electronic medium (i.e., ease of manipulation and replication) but preserves the ability to sketch may encourage designers to continue to sketch farther into the process. Other research has suggested that prolonging sketching, and therefore the ambiguous representations that are produced by sketching will result in a broader exploration of the design space [9].

Informal interfaces leverage modes of interaction and communication that are already familiar to users. This means that a good informal interface should be relatively easy to learn and use. As described in the previous section, ease of learning and use will be critical to the acceptance of any new design tool.

Since the need to present polished design ideas to clients early in the process is one of the factors driving an early conversion to formal representations, a sketch-based tool should support the integration of sketches with more formal representations produced in other tools such as PhotoShop or Illustrator. We plan to explore whether or not designers will take advantage of the ability to integrate formal and informal representations to continue to sketch later in the design process.

Through this study, we were able to focus our understanding of where in the process an informal tool would fit best, and which specific types of design (and designers) it would best support. Our focus is now on the design exploration phase, and on information and navigation design. Later design phases require greater precision and probably would not benefit greatly from a tool with an informal interface. These phases also place a greater emphasis on graphic design. While an informal tool may not explicitly support later design phases, it should support transitions into them. One way we plan to do this is through integration with other media and representations as mentioned above. In particular, we found that presentation and word processing software are especially prevalent in designers' work practices. A web design tool should strive to integrate well with these applications, as well as with graphics applications such as PhotoShop.

Before undertaking this study, our plan was to develop a tool to allow designers to design finished web sites by sketching. Through this study, we learned a great deal about the intermediate products of the design process and all that happens between exploration of design ideas and the production of a completed web site. The production of finished web sites involves a mode of thinking and expression which is much more precise than the mode used by designers when exploring the design space. We now think it is important to concentrate on supporting creation of other artifacts, such as site maps, storyboards, and schematics, which are more relevant to the early design process than finished web sites.

Designers use multiple representations throughout the course of the design process. These representations depict the site at different levels of detail. A design tool should support a similar range of representations. Such a tool would be an improvement over the current state of the art, in which different representations are created using separate, poorly integrated tools. Several designers expressed a wish that the different representations could be tied together in a unified framework so that consistency and coherent project management strategies could be more easily maintained. Designers also expressed a desire to have a unified way to manage different *variations* of design ideas. Variations play a key role during the design exploration phase, and it would behoove an effective design tool to help support their creation and management.

Paper has many affordances, independent of the affordances of sketching. We would like to explore ways to integrate paper directly with an electronic tool so that designers can continue to use paper sketches while still gaining the advantages of an electronic tool. This integration could occur, for example, by incorporating scanned sketches or sketches done on a CrossPad™ into the site framework. Another way that this integration could take place is to allow the spatial arrangement of paper sketches or handwritten notes (similar to the Affinity Diagramming technique mentioned above) and the capture of this arrangement via cameras. We briefly describe such a system below.

TWO WEB DESIGN TOOLS

Based on the results of this study, we have developed prototypes of two applications to support web site design.

DENIM [16] is a system that helps web site designers in the early stages of design. DENIM supports sketching input, allows design at different refinement levels, and unifies the levels through zooming. In particular, DENIM supports visualizations matching the *site map*, *storyboard*, and *schematic* representations described in this paper. The current version of DENIM does not support integration with other applications, nor does it support transformations to more finished representations.

The Designer's Outpost [13] is a tangible user interface that combines the affordances of paper and large physical workspaces with the advantages of electronic media to support information design of web sites. Designers interact with the system by writing on physical Post-it Notes, arranging them on a desk in related groups, and drawing links between them. The system tracks the Post-its using computer vision and captures links among Post-its and groups with a stylus. Presently the Designer's Outpost, like DENIM, is not integrated with other tools and cannot produce finished representations.

CONCLUSION

We have described a study of web design practice consisting of interviews with professional designers and the collection and observation of work artifacts. The results of the study, including observations of common design processes and types of intermediate artifacts are also described. It was observed that designers use multiple representations of web sites during the design process, and that each representation is tailored to focus on different aspects of the design. Designers often sketch on paper early in the design process in order to quickly explore design ideas and to keep from focusing on low-level details too early in the process.

Based on our observations of design practice, we have outlined features for informal computer-based tools to support early-phase web design practice and briefly introduced two applications that incorporate some of those features. We believe that such tools will fit more comfortably into the design process followed by designers and give us an opportunity to test the principles of informal interfaces in a domain where the benefits can be clearly seen.

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