User Interface Design Principles for Interaction Design

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In recent years, the number of computationally-based devices has grown rapidly, and with them the number of interfaces we encounter. Often, the face for today's product or service is, at first touch, an interface. While the pervasiveness of the interface might present a minor challenge for the majority, for those with little previous knowledge or accessibility limitations the challenge can be insurmountable. In many cases, the way we access and use, and even the degree to which we rely on technology, may be vastly different from generation to generation.

As the number of interfaces and the diversity of users grow, the need for effective interface design increases. Clocks on VCRs and DVD players flash at users insistently demanding to be reset, a mute testimony to the failure of the interface. Designers commonly mimic standard interface design elements such as icons and metaphors, or create flashy interfaces that may appeal visually, but often at the expense of user understanding and functionality. Despite mimicry, creativity, new technology, and a steadily growing need, interfaces are mired in paradigms established decades ago at a time when user interface was more a computer novelty than a part of everyday life.

Thus far, pundits, consultants, and authors have attempted to improve interface design primarily by exploring and analyzing existing patterns of interface design, or by defining desirable end-user experiences.

One example of a detailed analysis of an existing pattern is the Nielsen Norman Group's 106-page report, "Site Map Usability."[1] A site map is a means for quickly gaining an overview of a Web site. The report mentions a principle in the first sentence of the executive summary: "Help users understand where they are"; then analyzes in great detail a specific means or pattern for meeting that need such as "Web site maps," delivering twenty-eight guidelines "to improve site map usability." Another recent example is Duyne, Landay, and Hong's book *The Design of Sites*,[2] which focuses on using existing patterns to improve Web interface design. As helpful as such approaches are, the examination of an existing pattern such as the site map, and a detailed recipe for the execution of that pattern, is not designed to stimulate innovation.

1 Nielsen Norman Group, Site Map Usability (Fremont, CA, 1998).

2 Douglas K. van Duyne, James A. Landay, and Jason I Hong, *The Design of Sites* (Boston: Addison-Wesley, 2003).

Two examples of desirable end-user experiences are the often cited "easy-to-use" and "intuitive." These recommendations have two problems: they are too vague to be useful and, as final experiences, they provide no indication of how they may be achieved. Jef Raskin, in his 1994 article noting the vagueness of "intuitive interface" as a measure of user experience,[3] maintains that the common usage of intuitive interface really means "familiar"; that is, an interface that resembles or is identical to something else. However, if familiarity is the criteria for success, then creativity and novelty certainly will suffer. In a field in which improvement is needed, a focus on familiarity will simply reinforce an unacceptable status quo. In his article, Raskin notes the tension between improvement and familiarity, suggesting that if intuitive is defined as familiar then "'Intuitive' may well turn out to be one of the worst qualities it (a new interface paradigm) can have."[4] Because Raskin wrote in 1994, it may be tempting to think that such advice is passé, but this is not true. Catherine Courage and Kathy Baxter's recent book *Understanding Your User,*[5] published in 2005, is intended to be a practical guide to user requirements. It defines useable products as "easy to learn."[6] Even if "easy to use/learn" or "intuitive" were defined precisely, it still would describe an outcome without offering the means to achieve it.

The Need for Principles

W. Ross Winterowd, in his introduction to *Contemporary Rhetoric*, writes, "A conceptual framework is a schema—sometimes diagrammatic—that serves two purposes. It allows one to organize a subject, and it automatically becomes an inventive heuristic for the discovery of subject matter."[7] This paper argues that what designers need to improve interface design is a conceptual framework that can spur innovation. We describe that conceptual framework first as "parameters" essential to an interface, and then as a set of "principles" to achieve an effective interface. The parameters and principles were arrived at through inductive study and, we hope, as Winterowd suggests, that they will have the power to not only organize material, but also drive inventive development.

Design principles, as we conceive them, consist of clear rules of thumb that have defined features, similar to the excellent examples found in Edward Tufte's books *The Visual Display of Quantitative Information* and *Visual Explanations*.[8] The principles we propose here must be integrated with the parameters that define an interface. We propose that parameters and principles working together can drive innovation and empower designers or any creative person charged with developing an interface. If the principles are founded appropriately and crafted properly, they should guide the creation of effective interfaces not only today, but facilitate the invention of novel interface approaches in the future.

3 Jef Raskin, "Viewpoint: Intuitive Equals Familiar," *Communications of the ACM* 37:9 (1994): 17–18.

4 Ibid., 18.

5 Catherine Courage and Kathy Baxter, *Understanding Your Users: A Practical Guide to User Requirements* (San Francisco: Morgan Kaufman, 2005).

6 Ibid.

7 W. Ross Winterowd, "Introduction: Some Remarks of Pedagogy" in *Contemporary Rhetoric: A Conceptual Background with Readings,* W. Ross Winterowd, ed. (New York: Harcourt Brace Jovanovich, Inc., 1975), 1–37.

8 Edward Tufte, *Visual Display of Quantitative Information* (Cheshire, CT: Graphics Press, 1983); and Edward Tufte, *Visual Explanations* (Cheshire, CT: Graphics Press, 1997).

Identifying Parameters and Principles through Design Research

Broadly speaking, design research investigates process, user, cultural context, form, and subject matter/content.[9] Design research as an applied research activity focuses on users and content. The design research process used for this project focused on content through the innovative use of content analysis techniques from exegesis: the science of interpretation. Our aim was to analyze interactive content in a thorough way. The premise was that a thorough understanding of the form given to content would lead student investigators to fresh insight into both interface as a form and the audience to which the interface was addressed. From this high level of understanding of interface and audience, investigators sought to define parameters and to describe principles to guide interface design. Our research focused on interaction with content in computational environments. By analyzing one specific type of interface interaction (content), what Kenneth Burke calls an "individuation" in his article "The Nature of Form"[10]. We derived concepts that are abstractions of many individual instances. As Burke argues in his article, the form given to content is revealing of both the author's thinking and the presumed audiences' experience. In Burke's words, "Form … gratifies the needs which it creates." Form is an essential aspect of design.

Interface as a formal tool also is significant in the field of Human Computer Interaction (HCI). In the past, HCI often has focused on interfaces primarily as tools that manage a computer or computer software. However, computer interfaces are no longer experienced only as tools for using computers, but as frameworks for exploring content. Many of the examples in Courage's and Baxter's book on user requirements, a basic HCI issue, are about content-oriented Web sites. Interface as a means to explore content is not just for the Web. One recent product example, the iPod®, is a small, portable computer with an inventive interface. However, the focal point of the iPod is neither the device nor the interface, but the content: music and video (in some models) are the stars. This anecdotal example suggests that product development generally, and HCI interface development in particular, are increasingly involved with developing interfaces for content. Because interaction with content typically is an individual expression of interaction, and because HCI increasingly deals with crafting content-oriented experiences, the principles derived from our study could apply to broader HCI issues.

What follows is a description of the design research process that led to the proposed parameters and principles of an effective content interface.

9 Design Council (www.designcouncil.org.uk).

10 Kenneth Burke, "The Nature of Form" in *Contemporary Rhetoric: A Conceptual Background with Readings,* W. Ross Winterowd, ed. (New York: Harcourt Brace Jovanovich Inc., 1975), 183–198.

The Process of Developing Interface Parameters

Overview

Our research method was inductive. After initially defining what an interface is, student researchers studied the principles of content interpretation, then selected successful content interfaces, and applied the interpretive principles to the study these interfaces. From looking at the structure of many content interfaces, students derived principles that made these interfaces successful. The derived principles then were consolidated and compared to previously published interface guidelines. The process was heuristic, and the goal was to discover design principles that were theoretically based, definitive enough to guide design, and yet timeless enough to guide interface development as technologies and techniques change. We recognize the dangers of starting with individual instances and from individual instances deriving useful general principles. One alternative approach already noted is to identify successful instances and codify these as patterns to follow, such as was done in Duyne, Landay, and Hong's book *The Design of Sites*. The difficulty of the pattern approach is the limit it places on innovation. Despite the authors' claim that "Our patterns direct your energies to solving new problems as opposed to reinventing the wheel," the purpose of a pattern is to provide something to follow, not the invention of something novel. Our purpose was different: describing principles that could spur innovation.

Interface Definition

We began by asking what the essential qualities—the parameters—of an effective interface are. Like many questions, we found the answer depended on context. Cooper and Reimann in their book *About Face 2.0*, state, "… there is no such thing as an objectively good dialogue box—the quality depends on the situation: who the user is and what his background and goals are."[11] In the 1992 version of "Macintosh Human Interface Guidelines" by Apple Computer, widely recognized as pioneering in user interface development, there are thirty-eight index entries for icons, but none for interface.[12] This suggested that interface and icon were nearly synonymous and that, logically, the best interfaces would be those with the best icons; and that those without icons would fail. This is clearly not the case, but suggests the extent to which interfaces had become mired in an existing pattern based on icons and a paradigm of interfaces as tools to manage software. We began to agree with Cooper and Reimann that what made particular patterns such as icons and dialogue boxes meaningful was something more basic than the patterns themselves.

A more general definition of interface was "the interaction between two systems" (*American Heritage Dictionary*). A more recent interface definition from Wikipedia, the online encyclopedia,[13] seemed closer to the point in defining user interface as: "The interface is the functional and sensorial attributes of a system (appliance,

11 Alan Cooper and Robert Reimann, *About Face 2.0: The Essentials of Interaction Design* (Indianapolis IN: Wiley, 2003).

12 Apple Computer, Inc., *Macintosh Human Interface Guidelines* (Boston: Addison-Wesley, 1992).

13 Wikipedia, "User Interface" (http://en.wikipedia.org/wiki/User_Interface). (Acessed: 08/25/2007).

software, vehicle, etc.) that are relevant to its operation by users." However, this definition emphasizes attributes over interaction, suggesting that interface is a thing and not a process. A bit closer to the point, Wikipedia goes on to describe user interface as having two essential components and two general means:

> The user interface is the aggregate of means by which people (the users) interact with a particular machine, device, computer program, or other complex tool (the thing). The user interface provides (the) means of: Input, allowing the users to control the system; (and) Output, allowing the system to inform the users (feedback).

User interface, by this definition, involves both users and "things." The interaction involves both inputs and outputs. For our study focused on content interface, students summarized that any interface has two basic considerations: users and content. A great deal is made in HCI literature about user-centered design and user needs. This suggested that, for users, interaction has a purpose or aim even if that aim is merely one of idle amusement. We therefore defined user interface as the means by which users interact with content to accomplish some goal.

Content Research

Armed with the interface definition above, faculty/student teams initiated a research project to identify the essential features of an effective content interface. We began with an examination of the characteristics of various kinds of content in order to understand how the nature of different content types might impact the design of an interface to that content. The particular inductive method we employed was based on "exegesis," an inductive method used for understanding texts. "Exegesis," a Greek loan word, literally means to lead or draw out (ex—out, hegeisthai—lead or think). Exegesis has been translated as "expound" or "explain," and today has come to mean the principles and methods used to draw the meaning out of texts; primarily religious texts such as the Bible. We drew upon a text-based research approach because we had limited the scope of our work to interaction with content rather than interaction more generally.

Respect for context and content type are the key principles of exegesis. Following these principles, students selected, analyzed, and compared the linguistic features of three different content types, ranging on a continuum from poetic to scientific proposed by noted author C. S. Lewis. The specific content types: poem, newspaper editorial (from an edition of the *New York Times*) and scientific report (from the *New England Journal of Medicine*), were intended to be representative of the full spectrum of content types.

Syntactical diagrams were created for each content type as a technique to analyze the structure and meaning of the content.[14] Word frequency, part of speech, and meaning were analyzed and compared. A typical finding was that scientific articles contain words with a high volume of very precise, often specialized meanings. On the other hand, poems use common words, often with atypical or unexpected metaphorical meaning: the words are not always used literally. Syntactical structures of each content type were similarly analyzed and compared. A typical finding was that poems do not speak in complete sentences, that editorials build arguments; and that scientific papers use rigid problem/solution structures with no personal references. The linguistic features were used to theorize authorial intention in writing the content and, by implication, the intended audience. Teams reasoned that the authors of scientific articles strive for precision in order to accommodate a small but specialized audience, while poets strive to create a general impression with a broad audience. Determining authorial intent through linguistic analysis is unusual in design research, but is integral to hermeneutics and exegesis; and the processes and techniques for it are well established.[15]

The result of this research was to define a continuum of "content types" bounded by two extremes:

A. Content Type Continuum: from the Scientific to the Poetic.

Scientific

Scientific information is explicit in the rules of interaction between user and content. It is clear, direct, and adheres to established content hierarchies and structures. It is accessible and often is thought of as part of a larger community of information that shares a common language and purpose. Scientific information usually is cross-referenced with similar and contrasting data, and typically is intended to share information and inform its audience without bias or emotion.

Poetic

Poetic information, in contrast, asks to be experienced. At a more practical level, poetic information may not adhere to the established content structure or hierarchy in favor of artistic or personal interpretation. Instead, it crosses boundaries and requires participation on multiple levels between user and content. Poetic information is categorical, conceptual, emotional, and usually includes sensory value.

The features of these of interactive content types were analyzed and compared to deduce their strategies for delivering content. In a departure from exegetical practice, strategies, rather than authors, were described since current media seldom has a single identifiable

14 Walter Kaiser, Jr., "Toward an Exegetical Theology" in *Web Style Guide: Basic Principles for Creating Web Sites,* Patrick Lynch and Sarah Horton, eds. (Grand Rapids, MI: Baker, 1999).

15 Ibid.

author. Four broad content delivery strategies were loosely defined: a "reference strategy" serving discrete bits of information to a specific inquiry; an "educational strategy" offering large quantities of information to teach about a more general topic; an "inspiration strategy" to motivate or inspire an audience and lead self-discovery; and an "entertainment strategy" to amuse or divert the attention of a generalized audience. Examples of each strategy were identified and their content analyzed. A profile of the supposed user was created. In some cases, the strategies themselves were given personae akin to the user profiles / scenarios employed in the development of interfaces.[16] Over time, these initial strategic descriptions have evolved into a continuum of four Content Delivery Strategies:

B. Content Delivery Strategies/Roles

Reference—The Librarian

A content delivery strategy designed to serve discrete bits of information to users. Reference delivery takes the persona of a librarian. Reference delivery is believable, and is connected to a much larger community of information. The reference source is driven to provide as much information as possible in as few steps as possible.

Educational—The Instructor

A content strategy designed to instruct, often in a step-by-step fashion. Unsurprisingly, educational delivery of content takes on the persona of a teacher. An educational or teaching delivery still maintains a high degree of believability and trust, but is more likely to be sequential and increase user knowledge through a series of learning or building steps than the cross-referencing librarian persona. The teacher, like the librarian, is driven to educate its audience.

Inspiration—The Speaker

A content strategy designed to motivate or inspire. Inspirational delivery takes on the persona of a motivational speaker. Often, the inspirational source has a more personal connection to the audience through calls to action and directives. The inspirational source derives its trust through emotional response and personal connection rather than through factual data.

Entertainment—The Actor

Finally, an entertainment delivery strategy is designed to amuse. It may take on the persona of an actor, and is geared to draw a browser audience. Again, it establishes a more direct connection with the audience and requires direct participation from the user. Entertainment sources are the

16 Cooper and Reimann, *About Face 2.0: The Essentials of Interaction Design.*

most open to interpretation, and may even require audience participation in establishing the content. In this scenario, the user is given a more authorial role than in the reference and educational strategies.

Student teams continued to follow an inductive process through personal interaction with various Web and interactive media experiences, in order to define significant parameters of the user. Although it is difficult to select only one means of describing the user, we focused on user intention as opposed to "user need," because every user action is not driven by need: one does not necessarily need to chat online with a friend. User intention also suggests the variability of a single user's approach to an interface from session to session, or even from moment to moment. Teams inferred the users' intentions that each interactive content strategy was designed to meet. Using "reverse engineering," students analyzed the content information structure and the interactive approach of interactive media in order to infer user intention. Students concluded that visual form is, in many cases, an indicator of user intention the media was designed to meet: data-oriented sites showed less concern on aesthetics, entertainment-oriented media more. Student reports raised questions such as: "Does the look of a reference site really matter, if all the user is going to do is go in, grab something, and head back out?" and "… www.m-w.com serves as a superb reference site, but probably is the worst looking site out there."

Like "content types," user intentions were described as a continuum bounded by two extremes:

C. User Intention Continuum: from the Hunter to the Browser
Max Bruinsma has said, "The Web encourages a predator's glance, processing a vast amount of fleeting information fast, before focusing on a target."[17] How a user chooses to interact with an interface often is determined by his or her purpose or intentions in accessing the content. In order to address this, we have broken user intention into two extremes of scale, that of the "browser" and the "hunter."

The Hunter
The hunter is focused, precise and often destination-driven. The hunter values the speed and efficiency of an interface, and rarely deviates from its initial content direction to discover a new path. Also, a hunter's final content destination is determined prior to the search while, at least initially, the browser may have no direction at all.

17 Max Bruinsma, *Deep Sites: Intelligent Innovation in Contemporary Web Design* (New York: Thames and Hudson, 2003).

The Browser

The browser is intent on the journey and, in many cases, may not have a final content destination in mind. The browser is less focused and driven in the search for content, and more likely to be open to new experiences. As an audience, the browser perhaps is more likely to notice and even be driven by the design of an interface.

A key difference between the users is their scanning behavior. The hunter may scan large quantities of information quickly in order to find a predetermined target information or content. The browser may scan that same information looking for a general topic, new pathways, or even a diversion. Quite simply, the hunter is driven by need while the browser is directed by personal interests or curiosity.

All content has an inherent structure. Content's inherent structure may be modified to fit a specific strategy, giving it a "strategic structure." This strategic structure takes the form of an interface in interactive content. An interface may be classified by the *structure* of the final content delivery. Four common interface types[18] were described to students: linear, hierarchy, matrix, and web. The assignment was to evaluate each of these in relation to the content types, content strategies, and user intentions; and to define how different user intentions and content types might be served by the interface structures. We determined that, based on inherent and strategic content considerations, efficient and appropriate interfaces can be created along four structural themes: linear, hierarchical, matrix, and web.

18 Patrick Lynch and Sarah Horton, *Web Style Guide: Basic Principles for Creating Web Sites* (New Haven, CT: Yale University Press, 1999).

Figure 1
Matrix of content delivery roles.

	REFERENCE	**EDUCATIONAL**	**MOTIVATIONAL**	**ENTERTAINMENT**
VOICE	content specific, clear and to the point, direct	clear. specific. uses accessible language in effort to inform audience	stimulating. intent is to inspire users. accessible language	vague and open to interpretation
AUTHORSHIP	values expert opinions	trustworthy, researchable authors	uses emotions to inspire trust rather than authorship	open, may require content participation from user to establish meaning
MOTIVATION	provide accurate data quickly. inform.	inform and educate	inspire and emotional connect. to stimulate	inspire and stimulate the audience. diversion.
CONTENT STRUCTURE	established content structure. cross-referencing and linking. most likely to be hierarchy	established content structure. accessible to large audience	less content structure, more open to interpretation	vague, open to interpretation
SCALE	links to much larger body of similar data	may be part of a larger community of data. can also be singular.	more often, a single site that may contain links to similar information	self contained and most likely to be linear in structure.

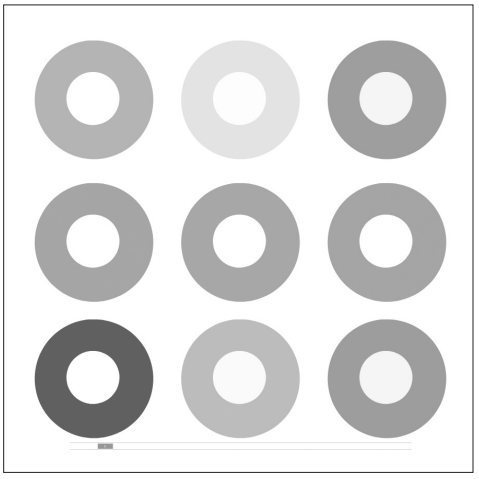
D. Content Structures

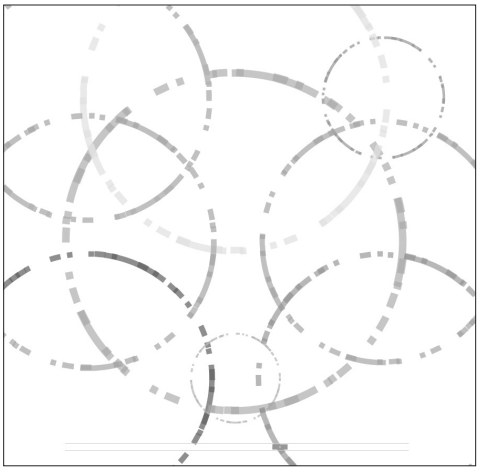
Linear

A linear interface is one that is fixed sequentially. Scientific content, having a fixed and sequential structure, is delivered step-by-step, with one additional piece of information following each successive selection. Instructions given following a teaching strategy would be well suited to a linear structure.

A linear interface is built with the following guidelines in mind:

1 Each successive step of a linear interface builds on the previous step.
2 The designer has the most control over the pace and amount of content a user can access.





Figures 2 and 3
Student example, Phillip Harvey.
Student exercise exploring linear interaction. The content progressed from a grid of nine static circles to a dynamic composition of line segments through the use of a segmented scrollbar.

Hierarchy or Tree Structure

The tree diagram or hierarchy is an interface that expands topically. In a hierarchy, several options may follow each selection. A hierarchy is suitable for content with a parent/child structure, and often is associated with a reference strategy.

A hierarchy interface is built with the following guidelines in mind:

1 A hierarchy, or tree diagram, is an interface that expands topically from broader topics to more specific topics in a branching fashion.
2 Several options follow each selection, depending on content structure.
3 Hierarchy interfaces should be efficient and allow users to access their desired content quickly and with a minimum of additional steps.
4 In a hierarchy, the content and user share control. In *The Language of New Media,* Lev Manovich states that "the user of a branching interactive program becomes its coauthor. By choosing a unique path through the elements of a work, she supposedly creates a new work." But it also is possible to see this process in a different way. If a complete work is the sum of all possible paths through its elements, then a user following a particular path accesses only part of the whole. In other words, the user is activating only a part of the total work that already exists.[19]
5 In a hierarchy, an independent value system determines the content structure (size, value, like content), and allows a user to access specific information quickly with a minimum of searching.

19 Lev Manovich, *The Language of New Media* (Cambridge, MA: MIT Press, 2002), 128.

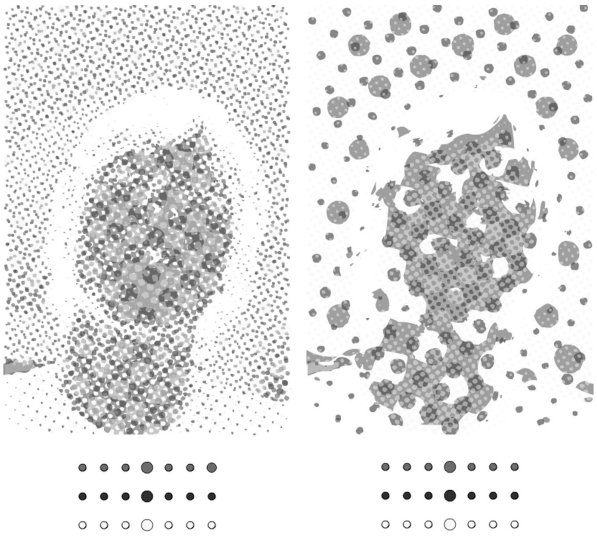


Figure 4
Student example, Ben Prince.
Student exercise exploring hierarchy.
Users controlled the content appearance through color, size, and resolution.

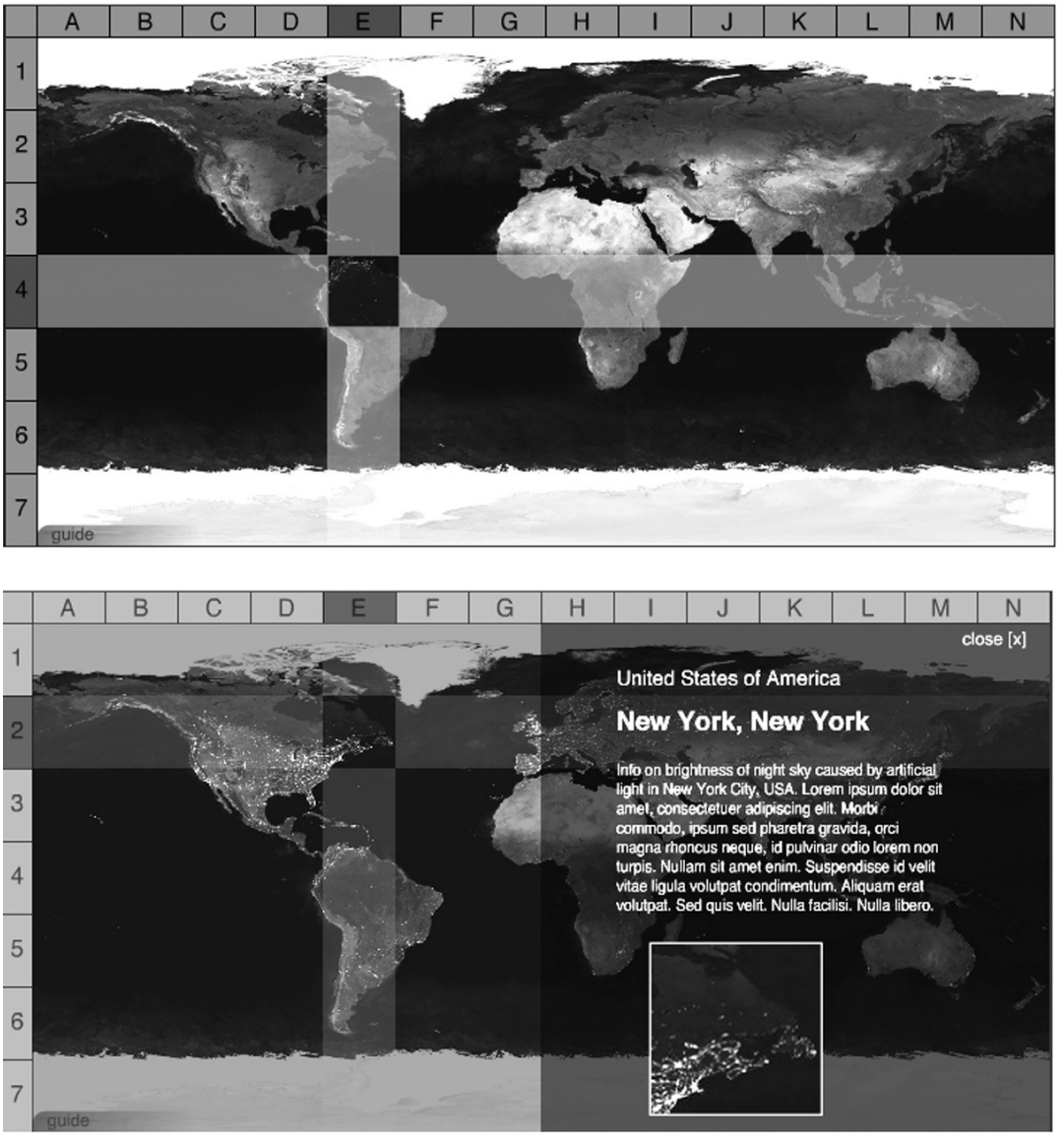


Figure 5
Student example, Ryan Devenish.
Student exercise exploring the matrix structure. Content about major cities was revealed through its placement on a grid.

Matrix

A matrix interface is one that simultaneously presents multiple relational options, usually organized by categories. A matrix is well suited to content with multiple related categories following a reference strategy.

1 A matrix interface presents multiple relational options simultaneously.
2 A matrix interface should be extremely efficient and allow a user to access a large set of data simultaneously in order to make comparisons and judgments about that data.

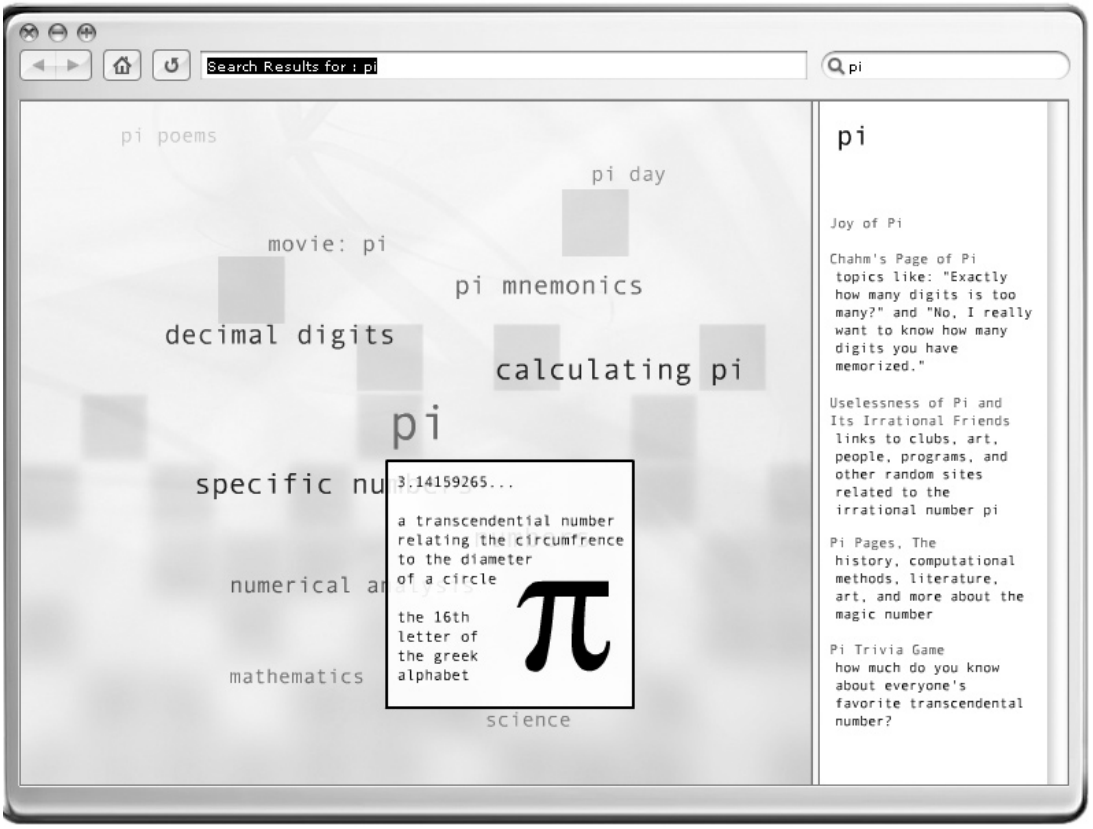


Figure 6
Student example, Tim King. Search results were place within a matrix based on how scientific or poetic the content was and how closely it related to the search query.

Web
A web is an interface freely associated cluster of undifferentiated items. It is useful for unstructured content following an inspirational or entertainment strategy.

The Process of Developing Interface Design Principles
Using the foregoing understanding of content type, content strategy, user intention, and content structure as a basis, teams of three to five students examined a variety of what they deemed to be successful Web site interfaces. Teams established a set of criteria for each interface that defined why these interface designs were successful. Individual team reports were presented to the full group. The group analyzed, compared, and synthesized their reports in an affinity diagram that resulted in the first draft of the design principles presented in this paper. The stated focus was to develop design criteria that a designer could apply. Emphasis was placed on not defining outcomes such as "easy-to-use," and on being specific as opposed to vague such as "intuitive." Questions such as "What makes this intuitive?" were repeatedly addressed to each principle. Once the principles were identified, they then were compared to published lists of principles in sources such as Patrick Lynch[20] and Apple, then consolidated further. An example of such a comparative list follows:

20 Lynch and Horton, *Web Style Guide: Basic Principles for Creating Web Sites.*

Table 1
Title goes here

Apple	Early / Zender Compared	Lynch
Metaphors	**Metaphor**	Clear Icons
Direct Manipulation	n/a	
See-and-Point	**Proximity: Concept Space**	
WYSIWYG	**Proximity: Physical Space**	Fewest Possible Steps
User Control	User Control	
Feedback and Dialogue	**Feedback**	Feedback
Forgiveness	**Reverse**	Return Easily / Go Back
Perceived Stability	**Landmarks**	Sense of Where You Are / Context
Aesthetic Integrity	**Content & Form**	Design Integrity
Modlessness	**(Feedback)**	
Knowledge of Audience	**[USER PARAMETERS]**	Disabled Users
Accessibility	**[USER PARAMETERS]**	Overview
	Subject Clear at Start	Screens
		No Dead Ends
		Bandwidth
		Simplicity and ...
	Consistent Logic	Consistency
	Conventions	Legacy (Graceful Degradation)

Early / Zender Original List
~~User Control~~
~~**Start**~~
~~**Reverse**~~
~~**Consistent Logic**~~
~~**Conventions**~~
~~**Feedback**~~
~~**Landmarks**~~
Efficiency
Customization
~~**Proximity**~~
~~**Concept & Physical**~~
Help
Content:
~~**Subject Clear at Start**~~
Interface in Content
Interface & Visualization
~~**Content & Form**~~
~~**Metaphor**~~

For further validation, this list was compared to a similar consolidated list "General Principles for HCI" in Dumas's chapter on basing design on expertise in human-computer interaction:[21]

Giving the user control
Striving for consistency
Smoothing human-computer interactions with feedback
Supporting the user's limited memory.

Following comparison and review, the various student lists were condensed into the following set of Interface Design Principles.

Interface Design Principles

A. Obvious Start: Design an Obvious Starting Point

A user must know how to start interaction with the content. In perceptual terms, "obvious" might be defined as visual form that is pre-attentively processed.[22] Pre-attentive features are proven to "pop-out" and include: size, value, hue, orientation, shape, enclosure, blurriness, and movement. Arguably, movement is the most basic pre-attentive feature, capable of attracting attention even in the periphery of our vision. Pre-attentive features should be applied using an "odd man out" principle, where the uncommon pre-attentive feature is the one that immediately stands out from its peers. For example, one red word in a paragraph will stand out. A continuum for this principle might be defined as from blatant to subtle.

A starting point is needed because every encounter with a new interface involves a learning process. Cognitively, we learn through finding patterns among details. In order to learn the interface, the user must know where to begin the learning process. This may seem obvious, yet often is overlooked. In the late 1980s, IBM, then still actively engaged in making typewriters, did an extensive redesign of their typewriter line basing the product revisions on extensive user research. One of the key findings was that the most fundamental problem with using the typewriters was how to turn the machine on: the user needed an obvious start button. The equivalent in architecture is to make the position and function of the door of a building obvious.

B. Clear Reverse: Design an Obvious Exit or Stop

The user must know how to reverse any action, including how to exit or end the session. Again, "obvious" might be defined as what is pre-attentively processed but, in the case of a reversal, "obvious" only is needed occasionally. Therefore, the reversal should become obvious "on demand," and should not necessarily pop-out continuously. The reversal should be omnipresent and clear but subtle. Subtle might be defined following Edward Tufte's concept of smallest effective difference.[23] The result would be present but unobtrusive. "Exit" may be defined as anything that stops or interrupts the current state. A familiar example of a reversal/exit is the "close window" feature common in both Mac OS and Windows operating systems.

"Reversal" is not simply the opposite of start. And exit is more than just the end. Knowing an exit route may provide the sense of confidence necessary to sustain an interactive session. Apple's "Guidelines" call this principle "forgiveness" and state that "Forgiveness means that actions on the computer generally are reversible. People need to feel they can try things without damaging the system."

21 Joseph Dumas and Janice Redish, *A Practical Guide to Usability Testing* (Norwood, NJ: Ablex, 1993). Elsevier, 2004).

C. Consistent Logic: Design an Internally Consistent Logic for Content, Actions, and Effects

Note: the most important consistency is consistency with user expectations.

Within an interface, a user must be able to quickly identify a logical, rational pattern of relationships between user actions and effects. By "internally," we mean within the world defined by the interface and its content. Design patterns should be consistent within the world the interface develops. To reinforce the pattern, a user must be able to depend on an acceptable level of consistency. For example, if buttons change form on hover, they should respond in a similar way or a logical extension of that way for a similar action. Consistency does not mean monotony. It is possible to design a rational evolution of relationships between user actions and effects throughout the interface experience. The actions and effects might change in logical ways as content changes. For example, as content becomes more detailed, user feedback sounds might become softer or higher in pitch. Uniformity is not the answer: logical progression and development that keeps interaction consistent with and reflective of content is. A user should find a logical consistency of all aspects of interaction, from visual form to motion, and the connections of these to content types. A continuum for this principle might be defined as from consistent to erratic.

This may be the most comprehensive principle for good interface design. It is based on human logic and cognition. When patterns are consistently and rationally connected to actions and content, users with average cognitive abilities will recognize the patterns and their meanings. Internal consistency is important because each interface creates a world that is distinct, though not isolated, from its immediate context (see the next principle for respecting conventions). Consistency reinforces learning and keeps the learning curve brief. Comprehensiveness builds a sense of reliability and keeps users from wondering whether different forms, words, situations, and actions mean the same thing.

22 Colin Ware, *Information Visualization* (San Francisco: Morgan Kaufman/ Elsevier, 2004).

23 Edward Tufte, *Visual Explanations*, 73.

D. Observe Conventions: Identify and Consider the Impact of Familiar Interface Conventions

Identify and respect a user's familiar interface language of words, phrases, images, and conventions. An interface does not need to obey all interface conventions familiar to a user, but it should violate those conventions with care. Respect might be defined as only violating a convention only when such violation gives a particular advantage or avoids a particular problem. Existing conventions can be built upon, extended, or even played with as appropriate for user and content parameters. A continuum for this principle might be defined as from observe to ignore conventions.

Users do not come to an interface as a blank slate, but rather with a host of previous experiences and expectations. Social and cultural experiences are preexisting conditions deserving respect.

E. Feedback: Design Tangible Responses to Apt User Actions

Users should receive feedback as they do tasks. Make the feedback as immediate as possible to the action in time and space. "Tangible" can be defined as feedback that is noticeable. Again, Tufte's concept of smallest effective difference might be applied here, making the effect of actions as minimal as effectiveness permits.[24] Keep the feedback proportional to action's importance. Feedback should be logically consistent and in alignment with content as noted previously. A continuum for this principle might be defined as from immediate and direct to delayed and disconnected.

Immediate feedback is necessary to keep users informed that their actions are having an effect. Apt feedback can be a form of reward for the user.

F. Landmarks: Design Landmarks as a Reference for Context

Users should have available information suggesting their location in the conceptual space of the interface. Design noticeable reference points, features, or landmarks that the user can identify. Some of these should be available at any time. These may be the equivalent of mile markers the user has passed, indicating progress; or behave as highway signs showing where they might go. A continuum for this principle might be defined as from clear or many to obscure or few.

Landmarks build upon users' ability to build a mental model of their experience. Landmarks are significant in the related field of "wayfinding" as it relates to spatial navigation. They also are significant in procedural knowledge as it relates to the logical or non-spatial mapping of information. Landmarks support the user's cognitive map, and help users identify where they are and where they can go in relation to the other aspects of the content.

G. Proximity: Design Interface Elements in Consistent Proximity to Their Content Objects and to Each Other

A user should not have to traverse great physical, conceptual, or time spaces to perform similar actions or access related content. There are at least three kinds of proximity: space, time, and concept. Good proximity in space builds on users' location memory by associating content and interface in a consistent or logical evolution of X Y Z space. Good proximity in time means content is available when the user wants it. Proximity in concept space means related items are grouped. An example of conceptual space is Apple's "see and point" menu system which groups related items into conceptual

menus. Cluster similar items spatially as well as conceptually. Design consistency in the spatial location of related objects. A continuum for this principle might be defined as from close to distant. Proximity is important because visual working memory has a spatial component that remembers the positions of up to three to five specific objects.[25] Proximity advantages this innate memory.

H. Adaptation: Design an Interface That Adapts or Is Adapted to Use

Allow users to tailor the interface to frequent actions. Design interfaces that identify and adapt to user segments. Envision systems in which the interface adapts itself to user needs or to patterns of interaction. For example, an interface could be envisioned that over time automatically minimizes or even eliminates infrequently used features or menu items. A continuum for this principle might be defined as from adaptive to inflexible.

Customization advantages different user intentions, and fits them to diverse content types even within one application. It acknowledges that users can be novices or experts with the interface, the content, or both.

I. Help: As Necessary, Provide a Readily Accessible Overall Mechanism for Assistance

Design a support source of last resort. Make it available, but keep it subtle. An example is the help feature in many software applications. However, do not use a help menu as a crutch for poor navigation. Recognize where complexity demands it, and provide help that is easy to search and linear in form when instructions are involved. A continuum for this principle might be defined as from available to distant.

J. Interface Is Content: Design Interface Elements That Minimize Interface and Maximize Content

A user utilizes an interface to get access to content. Therefore, content is paramount. The interface is part of the content, not merely a means to access content. Design the interface so that interaction is as direct with content as possible. Avoid interfaces that come between the content and the user. Wherever possible, make the interface part of the content, and not just an unrelated control. The interface serves the content, not the other way around. A continuum for this principle might be defined as from integrated to separated.

Every extra unit of information in a dialogue competes with other content. Interface elements, when divorced from content, can become noise that obscures the purpose of the interface.

24 Ibid.

General Design Principles

The following principles constitute good communication design practice and, as such, should be included in interface design practice, but are not specific to interface design. Every interface, by definition, engages a user with some content. It is logical for the interface to reflect the nature of the content in every possible aspect. The interface type should match the content type and user intention. For example, step-by-step instructional content is best presented with some variant of the linear interface.

A. Subject Matter: Make Subject Matter Obvious from the Start

A user should gain immediate understanding of the subject matter related to the interface. Design the interface so that in every aspect it expresses the content and content type.

Content types differ in nature and structure, and thus require different interfaces. Poetic content, ambiguous by nature, will not submit itself to hierarchical categories and information trees.

B. Interface Visualization: Use Visual Form Apt to the Content to Embody the Interface

Presenting information visually engages the user's ability to sense and feel; compacting much information into a quick, perceptual encounter. The power of computers to collect, store, and manipulate numbers far surpasses human capacity to understand that same data. As a result, the visualization of large quantities of information takes on great significance, transforming incomprehensible data into understanding.[26]

Humans have remarkable perceptual abilities to scan, recognize, and recall images, as well as to rapidly detect meaning in patterns and changes in size, shape, color, movement, and texture. Text requires more cognitive effort to understand content, because the relationship between form and meaning is somewhat arbitrary.

C. Content + Form: Design Apt Visual Form Based on Content

A user must be engaged by the formal visual qualities of the interface. Design an interface that is visually engaging, or aesthetically successful; which are essentially two ways of saying the same thing. The most apt visual form is one that reflects the nature of the content in a stimulating way. An interface that fails to engage and keep a user's attention has failed by definition: the user has disengaged and no longer interfaces with the object or content.

Museums can testify that people everywhere and at all times have desired visually engaging objects as cultural artifacts. Building a visually engaging interface applies this proven principle in order to engage and hold the interest of a user.

25 Colin Ware, *Information Visualization.*

D. Metaphor: Use Metaphors Where Content Is New, Obscure, or a Narrative-Based *Visual Metaphor*

Metaphors trigger memories and build associations. Use them where helpful, particularly when introducing new or obscure concepts.

The following is the essence of *Working with Interface Metaphors* by Thomas D. Ericsson:

> Metaphor is an effective tool in interface design in that it engages users more fully, allowing them the ability to use previous knowledge and experience to better understand current unknown experiences. A metaphor is an invisible web of terms and associations that underlies the way we speak and think about a concept. Metaphors function as natural models, allowing us to take our knowledge of familiar, concrete objects and experiences and use it to give structure to more abstract concepts."[27]

Integrating Interface Parameters with Interface Principles

To properly guide the design of an interface, we believe the principles for design proposed above in Section Two must be integrated with the parameters defining interface outlined previously in Section One. Principles in isolation do not provide sufficient guidance to inform design decisions. The principle "Obvious Start" comes from, and is mediated by, user intentions interacting with content type, delivery strategy, and content interface structure. For example, the obviousness of the entrance of an interface for a browsing user experiencing poetic content with an entertainment strategy composed in a web structure will be different from a hunter of scientific content.

Having defined a user interface as:
the means by which users interact with content for a purpose,

and having defined the Parameters that govern an effective interface as:
Content Type: Scientific – Poetic
Content Delivery: Reference - Educational - Inspiration – Entertainment
User Intention: Hunter – Browser
Interface Type: Linear – Hierarchy – Matrix – Web

and having established a workable list of best Design Principles:
Obvious Start:
Clear Reverse:
Consistent Logic:
Observe Conventions:
Feedback:

26 Marc Green, *Toward a Perceptual Science of Multidimensional Data Visualization, Bertin and Beyond* (Toronto: ERGO/GERO, 1998), 11.

Landmarks:
Proximity:
Adaptation:
Interface Is Content:
Help:

We can integrate the parameters and principles to establish a parameter | principle matrix that can guide design decisions. An example is described and graphically illustrated below.

A designer is designing an interface for poetic content: a movie promotion. The presentation strategy is a speaker because the film has documentary qualities, while the user intention is anticipated to be a hunter intent on finding specific historic references touched upon in the film. The content structure selected to support these conflicting needs is a matrix. To fulfill the principle of providing an obvious start to meet the above parameters, the designer might choose a start toward the subtle end of an obvious to subtle continuum. To create a subtle but effective start, the designer might select a fairly muted color on a bright-to-muted continuum, a small size on a large-to-small continuum, but an obvious upper left corner location, following Western reading direction conventions, on an obvious-to- obscure location continuum. The result of these decisions is illustrated on the following chart:

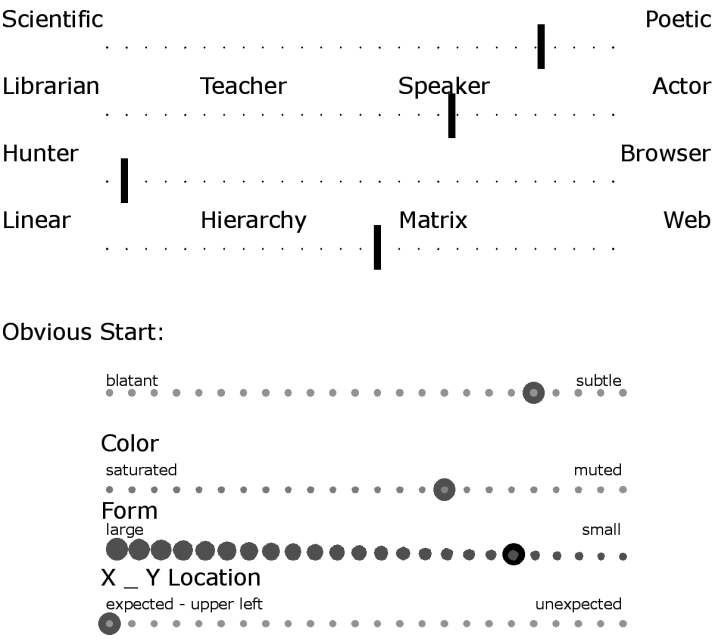


Figure 6
Student example, Tim King. Search results were place within a matrix based on how scientific or poetic the content was and how closely it related to the search query.

27 Thomas Ericsson, *Working with Interface Metaphors* (Boston: Addison-Wesley, 2001), 66.

Note that the decisions related to "obvious start" align roughly with the interface parameters above them, causing each design decision to be taken in reference to the specific interface parameters being addressed. While this process could be followed with each interface principle in turn: clear reverse, consistent logic, observe conventions, and so forth; in practice, consideration of a just a few principles generally leads to a design theme or system that encompasses the other principles. The process is not linear, but iterative and global, consistent with the principle of consistent logic. We believe this approach has great flexibility while accounting for all the relevant factors. The principles proposed are actionable, and have the potential to be measurable. While guidance is clearly prescribed and is based on the parameters of an interface, the means to accomplish such an interface are left completely open, inviting invention and innovation. Novel combinations can be envisioned and may even be encouraged. Recipes for making Web site maps are replaced by guidance in establishing landmarks and contexts for a particular user intention and content type. Gone are vague descriptions of end states; replaced by a creativity-expanding matrix of distinct possibilities aimed toward a target experience.

Need for Further Study

We have applied these design principles in a variety of classroom interface design projects clustered around the theme of content exploration and wayfinding in museum settings. The projects have produced interface prototypes. In applying these principles in the design of simplified and incomplete interface models, students have been able to explore ideas, elaborate requirements, refine specifications, and test functionality. These principles have given the designers a method to visualize, evaluate, learn, and improve design function.

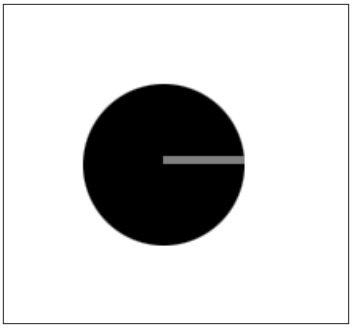
Even so, more work needs to be done.

Each of the design principles proposed in this paper should be defined so that its parameters are measurable. Unfortunately ours are not. Design theory and practice are woefully inadequate in defining visual form in quantifiable ways. If parameters are not measurable, they are not really attainable: they are just nice advice. The field of design is ripe with good advice, and while we are happy to add our voice to the chorus, that is not ultimately our aim. We hope to see research in design expand to include the features and functions of visual form so that design principles that relate to visual form, such as those proposed here, can be defined, measured, tested, and refined.

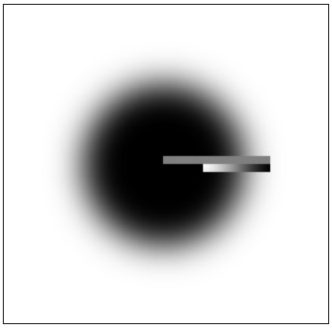
Through research in and out of the classroom, we have discovered that such definitions are possible. For example, the preattentive visual feature of blurriness, noted in the "Start" Principle, recently was defined in a student research project as the ratio of gray to solid pixels. Further, the point at which the ratio became

effectively pre-attentive, the point at which it popped out, was established. Through this study, it was determined that dark values project blurriness with less real physical blur than light values. Pushed further, a ratio of blurriness to background value might be developed quantifying the degree to which different amounts of blurriness pop out from their surroundings. These ratios could be applied to the "Start" and "Exit" principles, tested, and evaluated. Unfortunately, there are nearly a dozen pre-attentive features. This study barely explored one, and that one in isolation from the others. More studies such as this are needed to define effectiveness of visual form, and how it might be used to quantify visual attributes in interface displays.

Figures 7 and 8
Student example, Chrissie Talkington.
Initial research for the design principles noted in this paper. Blurriness example.



Blur Radius:
12 pixels black = Blur Ratio 1 : 0



Blur Radius:
6 pixels black, 12 pixels gray =
Blur Ratio 1 : 2

Summary

We believe it is clear that interface parameters and design principles can be combined in a way that to supports a design practice. We also believe that an integrated approach combining users, content, and form is comprehensive enough at a high level to guide the design of novel and effective interfaces. As a result of this study, it also is clear that more precisely defined parameters for visual form are needed in order to apply design principles in measurable ways. Without more detailed knowledge of the effects of the execution of visual form, the principles proposed above can only be applied intuitively. We believe that the next steps are to conduct research in visual form, and apply it to the proposed principles to define them in more measurable ways. Through continued research, we would like to convert intuition into significant knowledge so that designers can grow to make the kind of contribution to human understanding that we believe we are capable of making.