Usable E-Learning: A Conceptual Model for Evaluation and Design

Brad Mehlenbacher, Leslie Bennett, Tammy Bird, Melonie Ivey, Jan Lucas, Janet Morton, Lisa Whitman

NC State University
Raleigh, NC 27695-7801
brad_m@unity.ncsu.edu

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Abstract

Our goal in this paper is to outline the challenges facing researchers and practitioners interested in merging theories of usability design and evaluation with developments in e-learning. We provide a brief overview of usability research that is grounded in both early Human-Computer Interaction (HCI) research and in classical and contemporary rhetorical theory. Our motivation for doing this is to describe a conceptual model of instruction that affords both usability and e-learning researchers a common framework for approaching the exponentially-growing number of studies devoted to e-learning in general and the design of usable e-learning specifically. Rather than simply applying methods from usability research to the study of e-learning environments, we maintain that (1) usability research encourages a task-oriented perspective towards (e-learning) instruction that has implications for learning theory and (2) e-learning research broadens our traditional definitions of user, task, and context derived from usability to account for formal and informal learning environments. Finally, we share an heuristic tool that we are developing for evaluating e-learning environments and experiences. **Keywords**: heuristics, learning, model, e-learning, usability.

The fact that many serious and competent scholars can conclude that there has been little net productivity gain attributable to this [modern computing] technology seems enough proof that something is wrong. Landauer, 1997

1 Defining Usability

Usability evaluation finds its beginnings in early research on human-information processing theory (Newell & Simon, 1972; Simon, 1979, 1981) and Human-Computer Interaction (Card, Moran, & Newell, 1983). At the heart of usability evaluation is the application of social science research and theories of computer and information technology to the challenge of designing tools that are useful and usable to humans. Understanding humans as technology users necessitates an understanding of humans as audience, where audience is understood in the postmodern sense as actively engaged information producers and consumers (Ryan, 1994).

The audience-oriented designer's essential tension is between studying general design guidelines and principles derived from the research and in applying them to real design problems. The source of the tension between "general advice" and "specific design problems" lies with the design process itself: design is at its core both *constructive* and *argumentative*. Design is a *constructive* task in as much as it ultimately demands synthesis in an act of producing a technology; design is *argumentative* in that the designer must be able to justify design decisions, to assess critically the tradeoffs in alternative designs and, in general, to discuss design problems with others or persuade them to adopt particular solutions. Understanding audience, then, is where usability begins.

Audience as construct has received considerable theoretical treatment from classical and contemporary rhetoricians (Aristotle, 1926; Bitzer, 1968; Cicero, 1949, 1970; Miller, 1985). For effective communication to occur, the speaker or author must adopt the presentation and treatment of the message to those who will hear or read it. Not surprisingly, the principle of audience orientation and the goal of applying it to concrete information design situations is a complex proposition. Kinneavy (1971) represents all communication events as a triangle (p. 61):

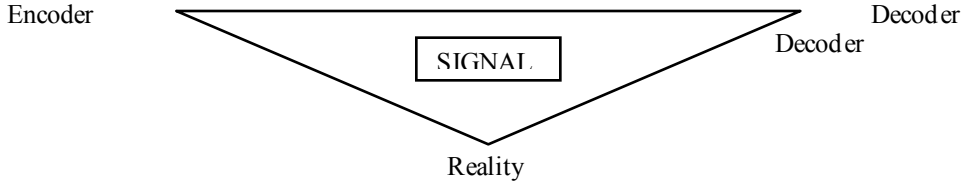

Figure 1: Kinneavy's (1971) Communication Triangle

The Encoder, or orator, framed by reality or a context for communicating, generates a message that, in turn, is understood and interpreted by a Decoder, or audience, in context. Extended to usability issues, a designer builds an interface (a complex, multilayered signal) within a given context of use that is understood and interacted with by a user. And, in the case of e-learning design, an instructor designs instructional lessons that are understood and responded to by learners in a given instructional context. Instructional "design" then is the act of combining the elements of content and display to effectively present the instructional content in a way that promotes learning through organized instructional resources and a user interface that is not confusing, dissatisfying, or cognitively taxing.

To address the multilayered challenge of designing an interface that meets the needs of users as learners, several interface attributes must be embodied in the design. Nielsen (1994), generalizing from usability evaluations of 11 applications and approximately 250 usability problems, has produced the following 10 heuristics for usable design:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation.

While some researchers have applied these heuristics directly to the testing of e-learning environments (Koohang & Weiss, 2003; Reeves et al., 2002), others (Squires & Preece, 1999; Zaharias, 2004) have argued for more synergistic collaborations between usability and e-learning researchers. After all, the HCI foundations of usability research began with a focus on studies of learning, specifically on novice-expert studies of humans playing chess and solving complex mathematics and physics problems (Chi, Feltovich, & Glaser, 1981; Simon, 1979). This shared interest in human tasks and on developing sophisticated methods for describing them (Jonassen, Hannum, & Tessmer, 1989) promises to contribute to the development of theories of e-learning usability. A usable e-learning environment, therefore, would be

- *Useful*: it does what we want it to do
- *Effective*: it allows us to perform our tasks quickly and proficiently
- *Learnable*: it enables us to learn how to do our tasks
- *Flexible*: it has system integrity and tolerates our errors (Lee, 1999), and
- *Satisfying*: it encourages us to continue using the interface (Bias & Mayhew, 1994; Dumas & Redish, 1993).

2 Extending Usability

The most natural and least troubling extension of usability evaluation to e-learning design is to design and test e-learning environments for how successfully or poorly they address Nielsen's (1994) heuristics for usable design. After all, at the most basic level, learners working in an e-learning environment can be described as users who have a set of tasks (ie., what did you *do*…?) that they want to accomplish within an e-learning environment (in class) using a given set of tools (via an interface).

Over the last twenty years, usability researchers and practitioners have applied their methods not only to hardware but to productivity software, direct-manipulation interfaces, secondary support systems, documentation, and most recently to e-learning environments. This is not incongruent with Dumas's (2003) argument that usability testing can be performed at various stages of most any designed product — with all software, hardware, audience types, for cooperative use, in various stages of design, and for all secondary support materials delivered with the primary product (p. 1099).

Oversimplified dramatically, usability is the study of the intersection between tools, tasks, users, and expectations in the context of use. A conceptual perspective towards e-learning design promises to support (1) researchers interested

in sorting through the exponentially-growing body of research on e-learning, and (2) practitioners interested in developing rigorous, replicable principles for the design of e-learning environments and instructional materials. However, before outlining our conceptual framework, it is useful to first define as explicitly as possible what we mean when we describe e-learning environments.

3 Defining E-Learning Design

Figure 2 is a snapshot of the interface and content of an e-learning course that has been offered numerous times at NC State University:

Figure 2: Graduate Course Materials Delivered via WebCT Vista at NC State University

The online graduate course is entitled *Methods and Techniques of Training and Development* and the course is delivered via the WebCT Vista e-learning environment, an enterprise-level (ie., complex) Learning Management System (LMS) that includes various tools for facilitating discussions, document sharing, calendaring and course management, and for tracking learner progress in a course. The four boxes that frame the snapshot above highlight the multiple levels of interaction that all learners (in this case, instructors-as-learners) are assumed to understand: the browser interface, the WebCT Vista features, the online course structure and organization, and the instructional materials that make up the course. One can quickly surmise that expecting users to manage the numerous levels of interaction required to accomplish their learning tasks online is not a minor statement of faith.

Indeed, Relan and Gillani (1997) define Web-based instruction or e-learning as "the application of a repertoire of cognitively oriented instructional strategies implemented within a constructivist … and collaborative learning

environment, utilizing the attributes and resources of the World Wide Web" and they elaborate on four instructional strategies that can be employed in e-learning:

- As a resource for the identification, evaluation, and integration of a variety of information;
- As a medium of collaboration, conversation, discussions, exchange, and communication of ideas;
- As an international platform for the expression and contribution of artistic and cognitive understandings and meanings, and;
- As a medium for participating in simulated experiences, apprenticeships, and cognitive partnerships (p. 43).

Because of our emphasis on users and tasks or on learners and instructional activities, we draw on Collins and Berge (1995) who focus on e-learning activities rather than on instructional strategies. Collins and Berge (1995) list the following activities as making up the host of possible types of interactions that e-learning users can engage in:

- Mentoring, such as advising and guiding students;
- Project-based instruction, either within the classroom or in projects involving community, national, or international problem-solving;
- Guest lecturing, which promotes interaction between students and persons in the larger community;
- Didactic teaching, that is, supplying course content, posting assignments, or other information germane to course work;
- Retrieval of information from online information archives, such as OPACs, ERIC, and commercial databases;
- Course management, for example, advising, delivery of course content, evaluation, collecting and returning assignments;
- Public conferencing, such as discussion lists using mainframe Listserv software;
- Interactive chat, used to brainstorm with teachers or peers and to maintain social relationships;
- Personal networking and professional growth and such activities as finding persons with similar interests on scholarly discussion lists;
- Facilitating collaboration;
- Individual and group presentations;
- Peer review of writing, or projects involving peer learning, groups/peer tutorial sessions, and peer counseling;
- Practice and experience using emerging technologies that may be intrinsically useful in today's society; and
- Computer-based instruction, such as tutorials, simulations, and drills (pp. 3-4).

So e-learning environments that facilitate learning must balance a complex set of learner-as-student and learner-as-instructor goals and activities. They must be

- Efficient (in terms of resources, task support, and time)
- Ergonomically Effective (have the capacity for producing desired results)
- Economical (in terms of time and resources for learners, instructors, and tertiary users)
- Educational (in facilitating and promoting learning), and
- Equitable (equally usable by all learners).

4 Rethinking Instruction

Instruction, at the most basic level, involves the transmission of declarative or conceptual knowledge (facts, concepts, principles) and procedural knowledge (tasks, actions) from an instructor or instructional "text" (where contemporary texts can include video, audio, simulation, or multimedia objects) to a learner. Online instruction, moreover, involves an interdependent relationship between these levels of knowledge in both the instructional content (domain knowledge) *and* the instructional environment (operating knowledge).

The common position towards e-learning is that, as Nichols (2003) echoes, "The choice of e-learning tools should reflect rather than determine the pedagogy of a course; *how* technology is used is more important than *which* technology is used" (p. 3). Drawing on the focus of usability research, we can simplify face-to-face instructional situations to involve tools (whiteboards, chairs, etc.), tasks (read this poem, solve this mathematical problem, measure this flame), learners (with particular biological, cognitive, affective, and socioeconomic attributes), expectations or instructor objectives, and contexts for learning. While it is acceptable to maintain the position that substantial learning can be difficult, a usable instructional method would, ideally, minimize the cognitive load or perhaps more accurately the cognitive dissonance required to acquire and understand new concepts.

It is useful, then, to generalize to *all* instructional situations before immediately turning to e-learning environments (Mehlenbacher, 2002). See Table 1 for an elaboration of the five dimensions of all instructional situations:

Table 1: Five Dimensions of all Instructional Situations

Dimensions of all Instructional Situations	Relevant Activities or Attributes
Learner Background and Knowledge	Ability to apply skills, learning and technology experiences, standardized test taking and general educational success, life experience, age, gender, intellectual abilities, attitude, and motivation
Learner Tasks and Activities	Actions with learning materials, exercises, goals, processes, e.g., reading to learn, reading to learn to do, reading to analyze, reading to compare, confirm, correct, submitting to computer
Social Dynamics	Interaction with instructor and peers, responsiveness, social abilities, personal style, strategies for scheduling, group management, and self-assessment
Instructor Activities	Communication of content, set objectives, information exchange requirements, topic pacing, sequencing, adaptation to audience, methods of evaluation, strategies for topic elaboration
Learning Environment and Tools	Selection of instructional materials, e.g., reading and writing tools, individual and shared documents, viewing and dissemination methods, atmosphere that promotes mentoring and open exchange of ideas and discussion; ergonomically designed for optimal usability

4.1 Learner Background and Knowledge

The primary audience for e-learning environments is *learners* and the secondary audience is *instructors*. We also acknowledge that numerous tertiary audiences are involved in contributing to sophisticated online courses (e.g., instructional designers, technical specialists, administrators, program coordinators, support staff, and research and teaching assistants). Highlighting the multiple audiences that can be involved in the e-learning planning, design, implementation, delivery, and evaluation process is a critical first step in beginning to understand the complexity of the e-learning usability challenge. All learners of e-learning environments will bring the following general attributes to the learning experience:

- *Biological*
  - *Age*: children, adults, seniors
  - *Gender*: male, female, masculine, feminine
  - *Race*: Caucasian, African-American, Asian, etc.
- *Abilities*
  - *Cognitive*: intelligence scores, testing ability, educational level, metacognitive abilities
  - *Physical*: ambulatory, haptic, visual, auditory
- *Literacies*
  - *Computer*: training or education with technology, platform- and application-specific familiarity, adaptability, problem solving, task experience, novice or expert
  - *Domain*: knowledge of application area, education, testing capability, accredited expertise
  - *Textual*: knowledge of application area, education, testing capability, accredited expertise
  - *Visual*: experience with scientific and technical data visualization, spatial systems, simulation, and virtual reality environments
- *Socioeconomic Context*
  - *Income*: high, low
  - *Geographic*: rural, urban, low or concentrated populations
  - *Organizational*: large or small, private, public, educational or production
- *Personal Attributes*
  - *Learning style*: reflective, sequential, deductive, inductive
  - *Attitude*: orientation towards task, affective expectations
  - *Motivation*: self definition, esteem levels
  - *Self-monitoring*: strategies for assessing own learning progress

4.2 Learner Tasks and Activities

Mapping the relationship between learners and their goals and tasks is at the heart of any attempt to compare traditional face-to-face instruction with e-learning instruction. Indeed, Miller, Lehman, and Koedinger (1999) stress that "careful selection and analysis of the tasks that frame microworld use is essential if such environments are to lead to the learning outcomes imagined for them." Because e-learning "microworlds" are represented by and as computer interfaces, it is useful to understand the user activities that characterize any human-computer interaction (Mehlenbacher, 1992). In any online encounter, users must

1. Set an information goal or represent their task (ie., combine their prior knowledge, understanding of particular situations, and information goals to influence task behavior)
2. Navigate to new or related topics (ie., choose and select topics that they feel will "most probably" provide the information they need)
3. Scan the information (ie., search the online information to determine if it is relevant to their goal), and
4. Attempt to understand the information (ie., read the online text and graphics).

Importantly, these activities are usually prompted by cognitive dissonance and the general learner orientation, "How do I…?" or "I want to do is…." The challenge is to build e-learning environments that promote primary learning and task accomplishment and, therefore, that reduce secondary distractions due to ill-conceived user interactions. As Squires (1999) has asserted, how can usability goals "be contextualized in terms of the complex tasks involved in learning" (p. 465).

4.3 Social Dynamics

More than two decades ago, Williams (1981) wrote "a technology is always, in a full sense, social" (p. 227). Indeed numerous researchers (Brown, 2000; Chickering & Ehrmann, 1998; Squires & Preece, 1999) explicate social learning as including the following features:

- Cognitive apprenticeship structures
- Rich, timely feedback
- High learner-instructor interaction, and
- Cooperation and a sense of safety among learners.

Stelzer and Vogelzangs (1995) stress that the number one challenge facing the designers of e-learning environments is how to generate a high level of student-faculty interaction, given that the greatest difficulty experienced by online students is feeling isolated and keeping their motivation high. For this reason, Lynch (1998) emphasizes the importance of planning, early in the development process, for the integrated use of communication tools as part of the instructional goals of an online course. Carefully anticipating how Web pages, discussion lists, chat environments, whiteboards, commenting and annotation tools, and email or listservs will work *together* can allow e-learning designers to anticipate some of the general problems online learners and instructors are likely to encounter.

4.4 Instructor Activities

If Bernhardt, Wojahn, and Edwards (1990) are correct in asserting that the instructional activities of face-to-face classrooms have received limited attention, we can deduce that the same is true of e-learning instruction. Instructor activities drive most formal educational experiences and are organized around the presentation and pedagogical style of instructors and the flexibility of their content and media choices. Bransford et al. (2000) argue that, to employ technology effectively, instructors need to

- Develop expertise in subject content and teaching
- Develop understanding of theories of knowledge
- Develop understanding of pedagogy as a discipline
- Understand that principles of learning and transfer apply to them as learners
- Have opportunities to learn from recent research and cognitive discoveries, and
- Develop models for lifelong learning that guide their own career planning and teaching.

We recommend that instructors begin this ambitious program by reflecting on their teaching style, their instructional content, and the delivery media they intend to employ using broadly-defined instructional orientations (Reeves & Reeves, 1997; Vosniadou, De Corte, Glaser, & Mandl, 1996):

Table 2: Two Instructional Approaches Offering a Range of Orientations.

Instructional Approaches: Continua of Orientations	
From Reeves & Reeves (1997)	**From Vosniadou, De Corte, Glaser, & Mandl (1996)**
Pedagogical philosophy, from instructivist to constructivist	Interactive versus passive learning
Learning theory, from behavioral to cognitive	Fun versus serious learning
Goal orientation, from sharply focused to general	Natural versus efficient learning
Task orientation, from academic to authentic	Learner control versus chalkboard control
Source of motivation, from extrinsic to intrinsic	Grounded versus abstract learning
Teacher role, from didactic to facilitative	Scaffolding versus step-by-step learning
Metacognitive support, from unsupported to integrated	Modeling versus telling, and
Collaborative learning strategies, from unsupported to integral	Reflective versus reactive learning
Cultural sensitivity, from insensitive to respectful	
Structural flexibility, from fixed to open	

Viewing instructional situations, whether experienced online or off-, as consisting of the same five dimensions of learning allows us to select from a range of instructional strategies. The important question, then, is not which strategy is more or less effective but which strategy is more or less effective given ones audience, learning tasks, instructional goals, and learning context.

4.5 Learning Environment and Tools

The context of the face-to-face classroom is well known and has a documented historical and social evolution (Tyack, 1974). And instructors, learners, tasks (in the case of e-learning, instructional tasks that interact with interface feature tasks), and social dynamics all play out online in ways that are at least somewhat familiar to us. Further examination, however, reveals that many of our basic assumptions about and strategies for approaching these learning dimensions require modification simply due to a change in the learning environment. Drawing on the considerable research devoted to the usability of performance systems and e-learning design (Bevan, 1998; Nielsen, 1994, 1997; Mehlenbacher, 2002, 2003), we can begin to outline a set of heuristics for the designers of e-learning environments:

Table 3: Usability Heuristics for E-Learning Design

Usability Heuristics for E-Learning Design (1 of 3)	
Learner Background and Knowledge	
Accessibility	Has the WBI been viewed on different platforms, browsers, and modem speeds? Is the site ADA compliant (e.g., red and yellow colors are problematic for visually-challenged users)? Have ISO-9000 standards been considered?
Customizability and maintainability	Does printing of the screen(s) require special configuration to optimize presentation and, if so, is this indicated on the site? Are individual preferences/sections clearly distinguishable from one another? Is manipulation of the presentation possible and easy to achieve?
Error support and feedback	Is a design solution possible that prevents a problem from occurring in the first place? When users select something does it differentiate itself from other unselected items? Do menu instructions, prompts, and error messages appear in the same place on each screen?

Usability Heuristics for E-Learning Design (2 of 3)	
Learner Background and Knowledge, Continued	
Navigability and user movement	Does the site clearly separate navigation from content? How many levels down can users traverse and, if more than three, is it clear that returning to their initial state is possible with a single selection? Can users see where they are in the overall site at all times? Do the locations of navigational elements remain consistent? Is the need to scroll minimized across screens and frames within screens?
User control, error tolerance, and flexibility	Are users allowed to undo or redo previous actions? Can users cancel an operation in progress without receiving an error message? Are multiple windows employed and, if so, can they be manipulated easily?
Social Dynamics	
Mutual goals and outcomes	Are learners rewarded for using the communication tools? Are communication tools provided that allow synchronous and asynchronous interaction? Do communication tools allow information revision, organization, and management? Are interactions organized around instructional objectives and task deliverables?
Communication protocols	Are instructions provided for engaging with other learners online? Are documents, resources, and task instructions shared across learners?
Instructional Content	
Completeness	Are levels clear and explicit about the "end" or parameters of the site? Are there different "levels" of use and, if so, are they clearly distinguishable?
Examples and case studies	Are examples, demonstrations, or case studies of user experiences available to facilitate learning? Are examples divided into meaningful sections, e.g., overview, demonstration, explanation, and so on?
Readability and quality of writing	Is the text in active voice and concisely written (> 4 < 15 words/sentence)? Are terms consistently plural, verb+object or noun+verb, etc., avoiding unnecessarily redundant words? Do field labels reside on the right of the fields they are closely related to? Does white space highlight a modular text design that separates information chunks from each other? Are bold and color texts used sparingly to identify important text (limiting use of all capitals and italics to improve readability)? Can users understand the content of the information presented easily?
Relationship with real-world tasks	Is terminology and labeling meaningful, concrete, and familiar to the target audience? Do related and interdependent functions and materials appear on the same screen? Is sequencing used naturally, if sequences of common events or narratives are expected? Does the site allow users to easily complete their transactions or selections?
Interaction Display	
Aesthetic appeal	Does the screen design appear minimalist (uncluttered, readable, memorable)? Are graphics or colors employed aesthetically? Are distractions minimized (e.g., movement, blinking, scrolling, animation, etc.)?
Consistency and layout	Does every screen display begin with a title/subject heading that describes contents? Is there a consistent icon design and graphic display across screens? Is layout, font choice, terminology use, color, and positioning of items the same throughout the site (< 4 of any of the above is usually recommended)?
Typographic cues and structuring	Does text employ meaningful discourse cues, modularization, chunking? Is information structured by meaningful labeling, bulleted lists, or iconic markers? Are legible fonts and colors employed? Is the principle of left-to-right placement linked to most-important to least-important information?
Visibility of features and self-description	Are objects, actions, and options visible? Do users have to remember information from one part of a dialogue to another? Are prompts, cues, and messages placed where users will be looking on the screen? Do text areas have "breathing space" around them? Is white space used to create symmetry and to lead the eye in the appropriate direction?

Usability Heuristics for E-Learning Design (3 of 3)	
Instructor Activities	
Authority and authenticity	Does the site establish a serious tone or presence? Are users reminded of the security and privacy of the site? Are humor or anthropomophic expressions used minimally? Is direction given for further assistance if necessary?
Intimacy and presence	Is an overall tone established that is present, active, and engaging? Does the site act as a learning environment for users, not simply as a warehouse of unrelated links?
Environment and Tools	
Help and support documentation	Does the site support task-oriented help, tutorials, and reference documentation? Is help easy to locate and access on the site? Is the help table of contents or menu organized functionally, according to user tasks?
Metaphors and maps	Does the site use an easily recognizable metaphor that helps users identify tools in relation to each other, their state in the system, and options available to them?
Organization and information relevance	Is a site map available? Is the overall organization of the site clear from the majority of screens? Are primary options emphasized in favor of secondary ones?
Reliability and functionality	Do all the menus, icons, links, and opening windows work predictably across platforms? Have important interactive features and multimedia elements been tested across platforms and browsers?

5 Conclusions

We have outlined five dimensions of all instructional situations and connected them to an heuristic tool that we are developing for evaluating e-learning environments. Part of this process has involved elaborating on the historical relationship between information-processing theories of learning, HCI, and rhetorical theory. Currently, we are organizing and annotating the research on e-learning design and evaluation from over 30 research journals within the framework of our general dimensions of instructional situations. Three immediate benefits to this activity include (1) developing a rich taxonomy for organizing and interpreting emerging research on e-learning; (2) generating an heuristic tool for evaluating e-learning environments, and; (3) informing principles for the design of formal and informal e-learning environments and tools.

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