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A Model of Web Based Design for Learning

Richard H. Hall, Steve E. Watkins, and Vicky M. Eller

University of Missouri – Rolla

Abstract

In this chapter, we review a model that serves as a framework for the design of web-based learning environments. The model consists of seven basic components: directionality, usability, consistency, interactivity, multi-modality, adaptability, and accountability. We propose that effective design begins with a clear delineation of the intended audience, usage context, and learning goals and that all further design occurs within the context of these factors (i.e., directionality). The design factors themselves can be seen as representing the fundamental contrasting goals of simplicity (usability and consistency) and complexity (interactivity, multi-modality, and adaptability). We propose that effective design consists of the proper balance of simplicity and complexity. We also introduce a method we refer to as "progressive complexity", which is one potential method of achieving such a balance effectively, by offering the user a systematic set of options. Finally, design should include an evaluation component (accountability), which should in turn impact design modification via feedback. Evaluation, within this model, consists of learner variables, experimental methodology, outcomes, and measures. We review research that relates to the components of the framework, and also pose recommendations for development.

A Model of Web-Based Design for Learning

Framework

Figure 1 presents our framework for design of web-based learning environments. Three themes guide this model. First, an overriding direction, taking into account learners, context, and goals, should be carefully and thoughtfully identified as a first step in design, and this should serve as a guide for all further development. This difficult but crucial first step is often left out, or is forgotten once further design and development proceed. The direction of all design, development, and assessment should flow directly from the theme delineated. Second, proper design is largely a matter of striking the proper balance between elements of simplicity and complexity. New designers have the tendency to over-do "bells and whistles", including superfluous multimedia components that don't contribute to the learning goals. On the other hand, seasoned designers often focus strictly on elements of simplicity, usability, and consistency sacrificing dynamic and interactive components that could potentially enhance learning within the context of the objectives. We argue that effective design is a delicate balance between these two contrasting positions. Third, evaluation and assessment is a basic part of any design process, both formative and summative. Without this accountability component a designer never really knows how effective a given web-based learning environment is, and there is no mechanism for improvement in future design. This framework, which can serve as a guide for the design and development of web-based learning environments, will also serve as the framework for further discussion in this paper.

Directionality

A fundamental principle of instructional design for computer-based and web-based instruction is that thoughtful planning should proceed development. There is no question that this first step of developing an overriding direction, and developing a model for how to best translate this to the learner using web-based multimedia as a tool, is the most important step in the design and development process. Unfortunately, the process of analyzing the audience (the learners), of defining the usage context, and defining the learning goals is often overlooked.

The developer must take into account the intended audience (i.e., the learners) for the learning environment to be developed effectively. With respect to learners, research indicates that the most important factor in hypermedia performance is knowledge and experience (Lanza & Roselli, 1991; Dillon & Weston, 1996; Dillon & Gabbard, 1998). Of course, one advantage of web-based instruction is that the software can be adapted to the learner in various ways and this will be discussed below in the adaptation section. However, as a general rule of the thumb, a straightforward and consistent navigational structure will aid users who are less knowledgeable and experienced. Hypermedia research has consistently shown that low-ability novice users can become easily disoriented without clear guidance and consistency, while more advanced learners can benefit from the flexibility of a more complex navigational design (Shin, Schallert & Savenye, 1994; Dillon & Gabbard, 1998). However, this is not to say that all complex design elements, discussed below, will most strongly benefit the expert user. On the contrary, some elements of complexity such as the use of multimedia simulation and interactivity may be particularly effective for novices. Another popular set of learning variables that can be taken into account are learning styles (Gardner, 1993; Gardner, 1994; Sternberg, 1997). However, it's important to note that there is little experimental evidence that tayloring instruction to learning styles is effective (Pittenger, 1993; Brooks, 1997).

Web-based learning should be designed differently depending on the learning context or environment. One of the most fundamental context factors in web-based instruction is the setting (i.e. distance vs face-to-face). Although the purpose of this book is to provide guidance for distance educators, it is important to note that at this time there are still many more students learning in traditional face-to-face settings, and the web is also often used as an adjunct for these classes. Further, hybrid approaches which involve a mixture of face-to-face and distance approaches can also be effective (Horton, 2000). The important point, for the web-based instructional designer, is that the design of the class materials should differ signficantly for these different approaches. It is generally not a good practice to simply use materials designed for an entirely distance class as support for a face-to-face class, or vice versa. For example, materials for a class to be taught completely at a distance should contain more specific content and should be more self contained. Further, those who are designing for a purerly distance class should use download intensive media more sparingly, since the chances are students will be relying more on slower internet connections.

Althougha designer must consider the audience and the context in which web-based learning will take place, the most important factors in guiding the whole process of design and development are the learning goals. The goals of the learning should be clear to the designer and these should then be communicated to the learner. Of course real learning is more than simply memorizing facts, hence the learning goals should involve some sort of application and/or integration of foundational knowledge. The "problem based scenario" method, developed by Roger Schank (Schank & Cleary, 1995), is an example of a starting point that will lead to the development of effective modules. The first task for a designer, within the problem based scenario approach, is to identify target skills to be learned, and the rest of the scenario develops from there.

Design Factors

Once the overriding pedagogical plan for a given module or set of modules has been identified, a more detailed plan for the web-based learning environment is formulated. This process is basically one of balancing design components of simplicity and complexity. On one hand it is important that the designer create a module that is easy to navigate, downloads quickly, and includes only the most fundamental information. On the other hand, it is equally important that the designer create a rich and meaningful learning experience, which often requires dynamic and interactive media components that interfere with the usability of a module. It terms of the learner, the objective is to provide an experience that is novel, rich, and creative enough to keep the learning engaged and interested, while at the same time, creating and environment that is user-friendly enough to keep the learner from becoming overwhelmed and frustrated in such a way that it interferes with learning.

Simplicity

Usability. Within the context of our model, usability simply refers to all those factors in the software design that make the experience for the learner simpler and stress free. Technical problems and down load time can prove to be particularly important in a web-based environment. In fact, much of the literature that currently exists on web design focuses on the importance of usability and simplicity of design. This is perhaps most dramatically represented by “Usability Guru” Jacob Nielsen, who advocates web design devoid of bells a whistles, including graphics unless they are absolutely essential (Nielsen, 2000). For example, in his list of top ten mistakes in web design, number two is “Gratuitous Use of Bleeding Edge Technology” (Nielsen, 1996). The focus of Nielsen’s advice is for corporate sites when the goal is for the user to get information simply and quickly or to transact some business, so his views are not completely germane with respect to web-based learning.

Other common advice from those with experience in instructional web design focus on the need for simplicity in design. For example:

- Text presented on a given page should be limited (Cotrell & Eisenberg, 1997; Jones & Farquhar, 1997),
- Scrolling should be avoided (Shotsberger, 1996),
- Graphics and multimedia should be used only when they directly support the materials and serve a clear instructional purpose (DeBra, 1996; Cotrell & Eisenberg, 1997; Everhart, 1997), and
- Design components that increase download time should be limited as much as possible (Cotrell & Eisenberg, 1997).

Consistency. Within our design model, the term consistency to refers to the simplicity of the higher-order design elements of site organization. One of the fundamental advantages of hypertext is the potential for representing complex knowledge via multiple associative links (Frick, Corry & Bray, 1997; Reeves & Reeves, 1997). Unfortunately, the large amount of freedom and control that this allows the learner may be detrimental for the novice learner (Large, 1996; Niemiec, Sikorski & Walberg, 1996). In fact, there is a surprising amount of research with hypertext systems that indicates that including too much learner freedom can, contrary to expectations, decrease learning effectiveness (Large, 1996; Niemiec et al., 1996). This is not so surprising when one considers how complex, and novel, is the hyperspace for the average learner. This phenomenon has lead to the phrase, “lost in hyperspace” (Nielsen & Lyngbaek, 1990; Burbules & Callister, 1996). For this reason, one of the most important design principles, which is supported both by web-designer published experiences, and by research on hypertext learning environments, is that the learner should be provided with guidance (Jacobson, Maouri, Punyashloke & Christopher, 1995; Smith, Newman & Parks, 1997).

There are a number of ways that the web-based-training designer can combat the “lost in hyperspace” problem, and provide the learner with some guidance. The first method is to create a clear, and systematic organization scheme for the learning site (Schneiderman & Kearsley, 1987; DeBra, 1996). The usual/prototypical path through the pages should be obvious (Goldberg, 1997), and the information should be in a modular fashion within a well-structured hierarchy (Smith et al., 1997; Young & Watkins, 1997). In this same vein the main points should be obvious to the learner (Shotsberger, 1996). A clear organization also includes consistency in design across all the pages of a site (Shotsberger, 1996; Cotrell & Eisenberg, 1997; Everhart, 1997; Young & Watkins, 1997). The pages within a given site should not greatly differ in appearance within the same site and certainly within the same-level sections. The learner should be immediately aware if a hyperlink takes him or her outside the designer’s site.

Complexity

Interactivity. Interactivity is probably one of the most commonly used terms in discussions of computer-based instruction of all sorts. This is not surprising given that there is a large body of educational research indicating that learners learn most effectively when they are activity engaged in learning, as opposed to passively reading or listening (Brooks, 1997). Most of us recognize this intuitively, based on our own learning experience, despite the fact that so much of education involves passive techniques such as lecture. One of the great promises of computer-based and web-based instruction is that it can potentially facilitate the process of integrating activity into education. Interactive components of web-based software are those that require that the learner carry out some activity besides simply reading or listening. Hypertext, such as the World Wide Web, is well suited for increasing activity in that just requiring that the learner click through pages of hypertext in a non-linear fashion require a level of activity greater than traditional text-book/linear reading. More complex and rich activity can be added by requiring that the learner answer questions, locate specific information, research topics, and even create their own stories and scenarios.

Multi-Modality. Another fundamental potential advantage of web-based instructional tools in comparison to traditional text formats, is that the web offers the possibility of presenting materials in multiple (i.e., audio, visual, textual) modalities. A basic premise of cognitive flexibility theory, a popular theory of complex learning, is that students learn complex information most effectively if they are allowed to experience the information in various formats (Jacobson & Spiro, 1995). Further, basic cognitive research in multimedia learning indicates that dynamic simulations in combination with audio can be particularly effective for increasing student learning, so long as the audio is directly related to the information to be learned (Moreno & Mayer, 2000). It is also true that integrating rich and dynamic multimedia into the learning experience can increase student interest and motivation (Smith & Jones, 1989).

Dynamic multimedia on the web should not simply be a matter of transferring the classroom lecture to a computer screen (Horton, 2000). This is important, since video distance education is now being transferred to the web in many cases, and the easy strategy is simply to use the necessary video compression and simply transfer the videos to the web. Despite the compression techniques, this approach is download intensive and often requires additional plug ins. Further, this does not capture the personal nature of face-to-face lectures anyway. In short, it does not take advantage of the unique properties of the web. Instead, the presentation can be redesigned to take advantage of the strengths of the web format for enhancing learning. First, the lectures can be broken down into small segments and a front, back and pause button are added to provide the leaner with control and flexibility. Second, instead of just showing the learner the lecture simply as a "talking head", relevant dynamic graphics can be interspersed throughout the lecture that provide the learner with multiple representations and a framework for the lecture.

Adaptability. Besides the term interactivity, the term adaptability is probably the most commonly heard word when educational web designers are describing the learning environments they have created. One reason for the popularity of the term is that, within the educational community at large, the notion of tailoring learning to a student's preferred learning style has become a popular goal. Moreover, one of the great potential strengths of instructional hypermedia is that the instruction can be tailored to the learner in a number of ways. First, the learner can select a preferred format. For example, auditory learners could select audio instruction. Second, the web-module itself could collect information based on the learner's response to learning styles questionnaires, navigation patterns, or assessment performance. Unfortunately, although the idea of tailoring instruction to multiple learning styles has a lot of intuitive appeal, the efficacy of such an approach has very little support in the research (Pittenger, 1993; Brooks, 1997). Further, there is the fact that the creation of many versions of the same module is certainly going to require additional time and resources. Rather than creating learning environments that adapt to students learning styles or preferences, a more promising approach is to adapt learning to students skills and abilities, in that there is evidence that student ability is the single most important individual factor in determining students' performance with instructional hypermedia (Lanza & Roselli, 1991; Dillon & Weston, 1996; Dillon & Gabbard, 1998).

Progressive Complexity

The instructional web designer is often faced with a dilemma due to the conflicting need to introduce simplicity and complexity into the web-based learning environment. On one hand the designer can create a site that is primarily text, simple to navigate, and straightforward in content presentation. On the other hand, the designer can create a site rich in interactive multimedia, with elaborate demonstrations and simulations. The former is user friendly in that the site is highly usable and consistent, while the latter may very likely result in more effective learning, particularly for the novice who might require more elaborate content representation. One potentially effective method of addressing this dilemma is to present the user with multiple versions of the content in a progressively complex manner, from the simplest and most usable, to the most complex and interactive (a method we refer to as "progressive complexity"). The more complex versions are displayed only if the more simple displays do not result in effective learning. The criteria for effective learning can be based on the learner's own perception, or based on some embedded assessment and system feedback. In this case, the more complex versions would be presented if the learner did not pass some base-line assessment criterion. Thus, the additional download and usability cost associated with more elaborate displays only come into play if truly necessary. (Figure 2 depicts a progressive complexity design with three levels of complexity).

Accountability

The ideal assessment model consists of multiple methodological and measurement methodologies. In this section we will introduce four important characteristics of a thorough assessment model - learner variables, experimental methodology, outcomes, and measures.

Learner Variables.

Assessment studies should take into account learner variables in order to control for learner differences, and in order to examine the interaction of individual differences with Web-based modules in student performance. For example, as mentioned above, students who are more experienced and knowledgeable may benefit more from modules where there was an emphasis on complexity in design. As we pointed out in the adaptability section, there is evidence that student expertise is the most important factor in accounting for differences in performance with educational hypermedia (Lanza & Roselli, 1991; Dillon & Weston, 1996; Dillon & Gabbard, 1998). Although learning styles appear to play a less important role in determining performance with instructional hypermedia, it is our view that inventories based on Sternberg's thinking styles (Sternberg, 1997), and Gardner's multiple intelligences (Gardner, 1993; Gardner, 1994) theories, have the most theoretical and empirical support. There is evidence that the dimensions measured by inventories based on these theories can be important factors in how a given student learns most effectively (Gardner, 1994; Sternberg, 1997).

Experimental Methodology.

An ideal assessment program will employ four basic experimental methodologies, applied in a progressive fashion from formative to summative, as the program moves from design to development to application. In stage 1, *Software and Instructional Design Evaluation*, design is evaluated before the development of any software begins. *Basic research* constitutes the second stage. During this stage research on basic components of the educational innovations are carried out with relatively small samples of students. In these experiments a researcher/designer is freer to employ systematic and controlled experiments that focus on specific components of software design and also to solicit more detailed qualitative protocol from study participants. During the applied levels of research it is often difficult to use control groups for pragmatic and ethical reasons. In addition, it is difficult to do controlled comparison studies in applied studies due to methodological complications (Hall, Watkins & Ercal, 2000). The third stage, *Applied Research*, consists of research conducted within the context of actual learning environments. Initially, this can be carried out using prototype modules or series of modules. This will allow for assessment of specific modules and design factors within the context of classes and allows summative assessment to begin before all development is completed. Finally, applied summative evaluation can be carried out on the "final product" within the context of the learning environment for which it was intended.

Outcomes.

Important outcomes to be considered across experiments are learners' attitudes, problem solving and conceptual knowledge. Attitudes to be considered are variables such as course satisfaction, motivation, and perception of knowledge gained. Problem solving is assessed, both in terms of traditional computation problems and more advanced application problems. Finally, conceptual knowledge is assessed. Conceptual knowledge can be viewed as the recognition of structural relationships among course concepts, and the ability to apply this integrative knowledge to novel problems. This type of structural knowledge is a defining characteristic of expertise across science and technology domains (Glaser & Bassok, 1989; Royer, Cisero & Carlo, 1993).

Measures.

Outcomes are assessed using subjective (qualitative and quantitative), problem solving (basic and higher level), and pathfinder associative networks measures. The subjective measures are used to assess students' attitudes, motivation and perception of knowledge gained. The qualitative measures consist of open-ended narrative questions, and the subjective-quantitative items consist of Likert-scale (agree-disagree) statements. Questions and items are developed as appropriate depending on the goals of a given experiment. Problem solving measures can range from fairly simple computation problems with clear right and wrong answers to advanced/higher-level problem solving items that require students to integrate multiple concepts and to apply these concepts to novel "real life" problems. One of the most effective and well-researched ways to measure knowledge interconnectivity is via Schvaneveld's Pathfinder associative networks approach (Schvaneveldt, 1990; Johnson, Goldsmith & Teague, 1995), in which students rate the similarity of concepts, and a knowledge space is created using graphing techniques, which is subsequently compared to a prototype expert knowledge space.

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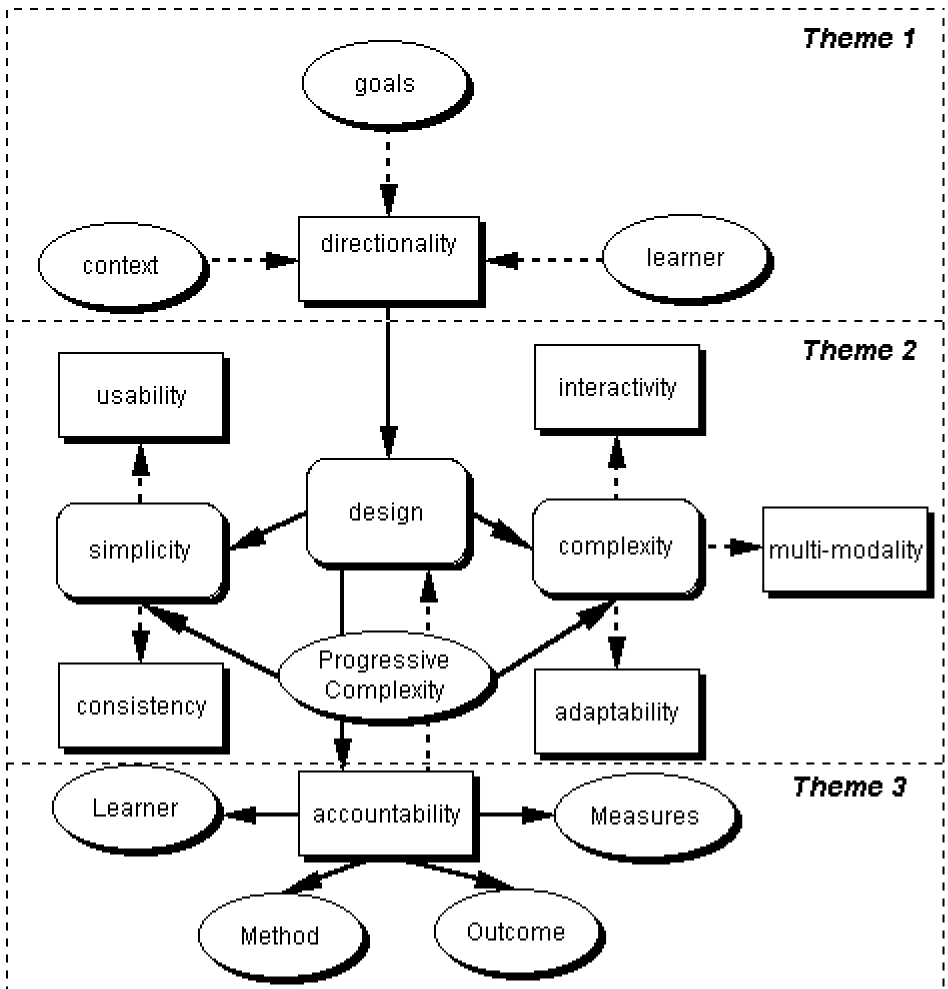
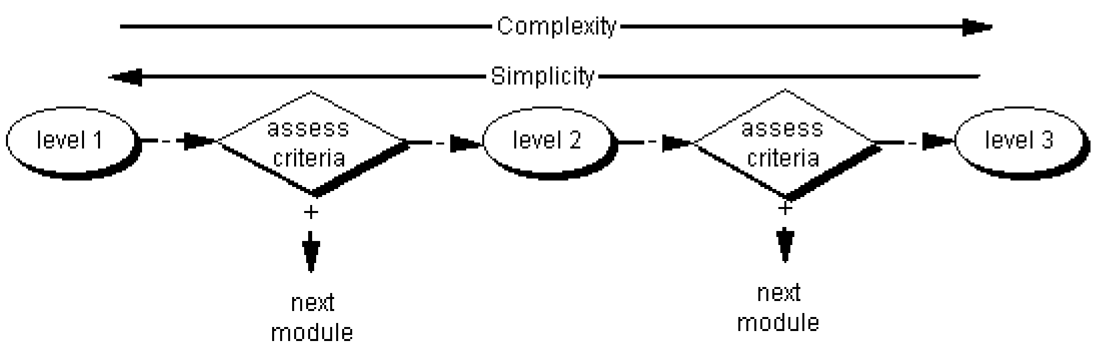
Figure Captions

Figure 1. Web Design for Learning Model. (Squares represent the seven basic components of the model.)

Figure 2. Progressive complexity design with 3 levels of complexity.


Theme 1
goals
context
directionality
learner
Theme 2
usability
interactivity
design
simplicity
complexity
multi-modality
Progressive
Complexity
consistency
adaptability
Theme 3
Learner
accountability
Measures
Method
Outcome


Complexity
Simplicity
level 1
assess
criteria
+
next
module
level 2
assess
criteria
+
next
module
level 3