running head: WEB-BASED DESIGN AND ASSESSMENT

Design and Assessment of Web-Based Learning Environments: The Smart Engineering Project and the Instructional Software Development Center at U.M.R.

Richard H. Hall, Steve E. Watkins, Robert Davis, Abdeldjelil Belarbi, and K. Chandrashekhara

University of Missouri – Rolla

in L.R. Vandervert & L.V. Shavinina (Eds.) *Provocative and Do-Able Futures for CyberEducation: Leadership for the Cutting Edge*. New York: Mary Ann Liebert, Inc.

Abstract

We present a framework for web-based learning design, which 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. Finally, design should include an evaluation component (accountability), which should in turn impact design modification via feedback. We review research that relates to the components of the framework, including a recent assessment on Web-Based modules as part of the PsychConnections project. We also pose recommendations and provide examples from the Smart Engineering Project and other instructional multi-media developed under the auspices of the Instructional Software Development Center at the University of Missouri – Rolla.

Design and Assessment of Web-Based Learning Environments: The Smart Engineering Project and the Instructional Software Development Center at U.M.R.

Framework

Figure 1 presents our framework for design of web-based multimedia for learning. Three overriding 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. It is too often the case that this difficult but crucial first step is 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, the learners, for the learning environment to be developed. With respect to learners, research indicates that the most important factor in hypermedia performance is knowledge and experience (Dillon & Gabbard, 1998; Dillon & Watson, 1996; Lanza & Roselli, 1991). 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, the more knowledgeable and experienced the learner, the more the elements of complexity can be emphasized and vice versa. 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 hypermedia design (Dillon & Gabbard, 1998; Shin, Schallert & Savenye, 1994).

Web-based multimedia will be used differently depending on the learning context or environment. Most of the literature that addresses the World Wide Web and learning has focused on the use of the web as a vehicle for learning at a distance. This is ironic, given that there are still many more students learning in traditional face-to-face settings, and the web has been integrated into these face to face classes on many levels. In the book, Web-Based Training, William Horton notes that there are a number of potentially effective ways to create "hybrid" web-based/classroom training (Horton, 2000). For example, in the U.M.R. Smart Engineering project web modules are used to provide students with necessary prerequisite knowledge. In the U.M.R., BEST Dynamics project, the multi-media modules are used to support and strengthen concepts taught face to face. In the PsychConnections project, the web-based modules are used to provide students with most of the basic information, and class is used for support. (Examples from all of the projects will be discussed below). While there is a growing body of evidence that indicates that purely web based classes can result in learning gains equivalent to the traditional classroom (e.g., Owston, 2000), there is also a growing body of evidence that traditional classroom instruction can be enhanced though the use of web-based multimedia. We'll provide one example of the latter in the section on assessment.

Although it is important that the designer 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, so it is important that the learning goals involve some sort of application and/or integration of foundational knowledge. We have found the "problem based scenario" method, developed by Roger Schank (Schank & Cleary, 1995), to be a particularly effective starting point for developing effective modules. The first task for a designer, within this framework, is to identify target skills to be learned, and the rest of the scenario develops from there.

For example, the Instructional Software Development Center is currently developing and implementing a “PsychConnections” project, which consists of a series of modules used to support Psychology Classes. An example of the use of the goal-based scenario method in this project is a module that covers cognitive dissonance theory. Our learning goals for this module, the scenario, and the assignment are displayed in Table 1. It is important to note that the final learning goal presented in Table 1 is the most important, and that all of the preceding goals are integrated into this final goal. In order to attain this goal we provide a situation involving a car dealership, so that the learner can immediately understand the problem within a context that he or she can relate to. We then provide them with a challenging “real life” problem that salespersons often encounter daily in an effort to enhance the learner’s interest and motivation. Finally, we ask the learner to apply what might initially appear to be a relatively abstract social psychology theory and experiment to this concrete and important problem, in an effort to come up with a solution. (Figure 2 is a screen shot from the web module.)

Design Factors

Once the overriding pedagogical plan for a given module or set of modules has been identified, a more detailed plan for the software is created. 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 for the learner, 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. These factors are particularly important in a web-based environment in which technical problems and down load time can prove to be particularly important. 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 most all of the 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). It’s important to point out that 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 relevant for web-based learning.

However it is also true that some of the most 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 (Cotrell & Eisenberg, 1997; Debra, 2000; Everhart, 1997).
- Design components that increase download time should be limited as much as possible. (Cotrell & Eisenberg, 1997)

In 1999, the University of Missouri – Rolla received an NSF grant for the integration of research with advanced multidisciplinary classes in engineering sensors, materials, and structures (Watkins, Belarbi, Chandrashekhara, Hall, & Nanni, 1998). A major component of this project is the development of web-based materials to support the classes. The principal purpose of these tutorials is to provide students from different disciplines with the necessary background information from non-major disciplines, in order to understand the advanced multi-disciplinary focus of the class. Since these tutorials were developed for those who were novices in the subject area there was an emphasis on usability elements in design. For example, despite the large amount of information to be included in the tutorials, text in each tutorial was limited to approximately 1,500 words. Further, graphics were created in such a way that they conveyed necessary information, yet were simple enough to speed download time. (Figure 3 is a screen shot from one of the tutorials).

Consistency. Within our design model, we use the term consistency to refer 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 particularly detrimental for the novice learner (Large, 1995; 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, 1995; Niemiec, Sikorski, & Walberg, 1996). This is not so surprising when one considers how complex, and novel, is the hyperspace for the average learner. This phenomena has lead to the term, "lost in hyperspace" (Burbules & Callister, 1996; Hill, 1997; Nielsen & Lyngbaek, 1990). 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, Mishra, Kolar, 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 (DeBra, 1996; Schneiderman & Kersley, 1989). 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, Newman, & Parks, 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. (Cotrell & Eisenberg, 1997; Everhart, 1997; Shotsberger, 1996;

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. An example from our own work is, again, provided by the Smart Engineering Project, in which a structured hierarchical menu is used consistently across all pages at the Smart Engineering Site. For example, the menu at the top of Figure 3 represents 3 levels (Level 1: Smart Materials and Sensors Class; Level 2: Sensors Section; Level 3: Prerequisite Modules), and the learners position within each level denoted with an asterisk. This menu is available to the learner on every page of the site, so that learner is always aware of his or her position within the site and can easily navigate to other parts of the site with a minimal number of mouse clicks.

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 requires 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.

A fundamental principle that guided the development of the goal-based scenario approach mentioned above, is that people learn by doing (Schank & Cleary, 1995), and this is the principle reason that we have adapted this method in Instructional Software Development Projects, such as the PsychConnections module (Table 1 and Figure 2). Another example of a set of interactive modules is the BEST Dynamics Project (Flori, 1997; Flori, Koen, & Oglesby, 1996), which is designed to support an Engineering Dynamics class. Figure 4 is an example of a BEST dynamics module in which a learner inputs data representing position, velocity, and acceleration and the program displays the results through dynamic simulation and numerical output.

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).

It is important to note that using 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. Such an approach doesn't take advantage of the unique strengths of the web. The Instructional Software Development Center is currently in the process of transferring video classes onto the web, but rather than simply compressing the video and presented it as a traditional lecture, the presentation is being redesigned to take advantage of the strengths of the web format for enhancing learning. First, the lectures are 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 are interspersed throughout the lecture that provide the learner with multiple representations and a framework for the lecture. (Figure 5 is a screen shot from one of these lecture modules).

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 (Brooks, 2000; Pittenger, 1993). 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 (Dillon & Gabbard, 1998; Dillon & Watson, 1996; Lanza & Roselli, 1991).

A straightforward knowledge-based adaptability approach is currently being developed as part of the Smart Engineering Project. These classes are ideal candidates for such an approach because the purpose of the classes is to promote interdisciplinary communication and the integration of knowledge from multiple engineering disciplines. Students come to the class with different knowledge bases and, in order to effectively learn the advanced interdisciplinary information, they require the necessary prerequisite knowledge. A schematic that displays the structure of the adaptive system presently being developed for the sensors section of the smart materials and sensors class is displayed in Figure 6. Before students begin working with pre-requisite modules (e.g., Figure 3), they complete a comprehensive pre-test which includes questions over all of the modules associated with a given discipline within a multidisciplinary class. The program then recommends tutorials based on performance. Following the completion of the tutorial, the student completes a post-quiz to again assess competence in the given area. In using this system, learners viewing material within their major can take less time than an out-of-major learner. For an interdisciplinary class the use of the web allows in-class activities to be equally stimulating to all. Also pre and post quizzes allows the instructor to monitor student progress and to insure that they are preparing before class. Hence, the instructor has a feedback mechanism.

Accountability

Model

The ideal assessment model consists of multiple methodological and measurement methodologies. In this section we will introduce the prototype assessment model that is currently being employed for the Smart Engineering and Instructional Software Development Center projects and then provide an example of a level 2 applied assessment (see model below) carried out in the context of a Physiological Psychology Class that used modules from the PsychConnections project. Figure 7 displays this prototype assessment model.

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 (Dillon & Gabbard, 1998; Dillon & Watson, 1996; Lanza & Roselli, 1991). 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; 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, *Level 1 Applied Research*, consists of research conducted within the context of actual classes 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. The fourth and final level of assessment, *Level 2 Applied Research*, consists of evaluation of the software within the context of entire classes.

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 (Johnson, Goldsmith, & Teague, 1996; Schvaneveldt, 1990), 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.

Example

Description. During a recent semester, students in a physiological psychology class at the University of Missouri – Rolla used Modules from the PsychConnections project that covered topics in Physiological Psychology. The modules were comprehensive in that all basic information for the class was conveyed via the World Wide Web. The basic format for the class was as follows. Monday was designated as "virtual lecture" day. During this day students were not required to come to class, though the instructor was available for individual consultation. On Wednesdays the class met, and this component of class was referred to as "professor's corner". Class would begin with the instructor answering class questions about the virtual lecture. Following this films that were related to the information presented in the lecture were shown. Before students watched the films they were provided with review questions that covered the films, and between each film the instructor discussed ways in which the film related to the information in lecture, and elaborated. Fridays alternated between class presentations, in which individual class members or teams would give presentations on a topic they had researched in depth, and eight class quizzes that covered principally information from the virtual lectures, and also some additional information contained in the films.

Method. In terms of the assessment model presented above, this assessment was a level 2 applied assessment in that the evaluation was carried out on the last class day and required students to evaluate their experience with the web-modules within the context of the whole class. The learner variable considered was ability, as measured by GPA and the outcomes considered were subjective, both quantitative Likert-Questionnaire items and open-ended questions. Students responded to eight Likert Items, on which they rated their degree of agreement with each item on a scale of 1-10. The statements related to their subjective rating of: a) virtual lectures on the web; b) professor's corner; c) a hypothetical traditional lecture (e.g., "I believe that traditional in-class lectures **would have** helped me to learn the necessary information for the class."); and d) the class project. For each of these four activities there was a statement about learning (e.g., "The lectures on the web helped me to learn the necessary information for the class.") and a statement about motivation (e.g., "The class project increased my motivation for physiological psychology.") The hypothetical traditional lecture item was included since we considered the comparison of the web lecture with a traditional lecture format important, and students did not have a traditional lecture format from this class to serve as a comparison. It was our view that the hypothetical lecture question would provide useful information since students have most likely had enough experience with traditional lectures in other classes to make an informed response to the item. For the subjective-qualitative open-ended question students were asked: "Did you find the lectures on the web effective? Why or why not?" and "Do you believe it would have been better if the instructor had used traditional in-class lectures rather than lectures on the web? Why or why not?"

Results. The quantitative analysis began with a series of Pearson Product Moment correlations to assess the relationship between GPA and student's ratings. GPA was correlated with all eight items and no significant correlations were found. In order to assess differences among the class activities and ability (GPA) a series of two, two-way mixed analyses of variances (ANOVAs) were performed, with format serving as the repeated measures independent variable in each (web vs. lecture vs. professor's corner vs. activity) and a GPA group (high vs. low) serving as a between subject independent variable. (GPA group was created with a median split). In the first ANOVA ratings (agree/disagree) for the learner items served as the dependent variable and in the second ratings for the motivation items served as the dependent variable.

In the first ANOVA a significant effect for activity was found $F(3,96) = 7.36$, $p < .001$. Tukey's post hoc tests indicated that students rated the web lectures and professor's corner significantly higher in amount learned than they did the traditional lecture and class activities. No other effects were significant in the first ANOVA. In the second ANOVA, no significant effects were found, although activity was marginally significant $F(3,96) = 2.49$, $p = .065$. The means for the ratings of the activities for learning and motivation are displayed in Figure 8.

The final stage of the quantitative analysis was a chi square performed on students' initial response to the second open-ended question. "Do you believe it would have been better if the instructor had used traditional in-class lectures rather than lectures on the web?" Of those students who answered the question directly, 6 said "yes" and 19 said "no". This difference was statistically significant [$Chi(1) = 6.7$, $p < .01$].

Consistent with students initial response to the question as to whether or not they would have preferred a traditional lecture, an examination of students response to the open ended items indicates that students were overwhelmingly positive about the web in comparison to their experience with lecture. The reasons that most students preferred the web could be broadly grouped into three categories: a) they found that reading was fundamentally easier than listening and trying to take notes form a lecture; b) they found the web more convenient in that it allowed students to work at their own pace on their own schedule; and c) they believe that the nature of the physiological psychology material lended itself to a web presentation. Comments from students who believed they would have preferred traditional lecture fell into the general areas of: a) Students learn better auditorily; b) Students can ask questions in a more timely and interactive way in a traditional lecture. (Representative responses to the open ended items are displayed in Table 2).

Implications for Design. One of the first things these results imply is that, based on students subjective views, we are on the right track in the design of our web environments. Students rated these environments as more effective for learning than a traditional lecture. Further, when students were asked if they would have preferred a traditional lecture approach they overwhelmingly said no. It’s interesting to note that very few students commented that it’s easier to ask questions in a traditional lecture, though this would seem intuitively to be an obvious advantage. This may very well be because stopping a lecturer and asking a question in a class full of other students may not be so easy in most lectures. Further, the instructor for this physiological psychology class examined here always answered emails with questions from students within 24 hours, and usually much sooner.

The design of the modules used in this class was clearly driven more by the simplicity components of the design model described above than the complexity components. The modules were short, clearly organized, and consisted mainly of text and simple graphics. Overall they were quite simple. This may account for the fact that students rated the modules so high with respect to learning, yet largely equivalent to traditional lectures, and substantially lower than the class project, in motivation. Given that motivation almost surely plays an important role in learning, especially in terms of higher level learning and transfer, we drew the implication that we need to include more interactive and multi-media components into the modules and are in fact integrating these in our current design. It's also interesting to note that ability, as measured via GPA, had no effect on students' responses to any of the formats. This may again have been due to the simple nature of the modules, and may well be a factor in the more complex modules that are currently under development. We will have to wait until assessment of the more complex modules is carried out in order to answer this question.

References

Brooks, D.W. (1997). *Web-teaching: A guide to designing interactive teaching for the world wide web*. New York: Plenum Press.

Burbules, N.C. & Callister, T.A. (1996). Knowledge at the crossroads: Some alternative futures of hypertext learning environments. *Educational Theory*, *46*, 23 – 50.

Cotrell, J. & Eisenberg, M.B. (1997). Web design for information problem-solving: Maximizing value for users. *Computers in libraries*, *17(5)*, 52-57.

DeBra, P.M. (2000). *Hypermedia structures and systems*. Retrieved May 23, 2000 from the World Wide Web: http://wwwis.win.tue.nl:8001/2L690/

Dillon, A. & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research*, *68*, 322 - 349.

Dillon A. & Watson, C. (1996). User analysis HCI - The historical lessons from individual differences research. *International Journal of Human-Computing Studies*, *45*, 619-638.

Everhart, N. (1997). Web page evaluation: Views from the field. *Technology Connection*, *4(3)*, 24-26.

Frick, T.W., Corry, M. & Bray, M. (1997). Preparing and managing a course web site: Understanding systematic change in education. In B. H. Khan (Ed.) *Web-Based Instruction*, Englewood Cliffs, NJ: Educational Technology Publications.

Gardner, H. (1993). *Frames of mind: The theory of multiple intelligences/tenth anniversary edition*. Basic Books.

Gardner, H. (1994). *Multiple intelligences: The theory in practice*. Basic Books.

Glaser, R. & Bassok, M. (1989). Learning theory and the study of instruction. *Annual Review of Psychology*, *40*, 631 – 666.

Goldberg, M.W. (1997). CALOS: First results from an experiment in computer-aided learning. *Proceedings of the ACM's 28th SIGCSE Technical Symposium on Computer Science Education.*

Hall, R.H., Watkins, S.E., & Ercal, F. (2000, April). *The horse and the cart in web-based instruction: Prevalence and efficacy*. Presentation at the annual meeting of the American Educational Research Association, New Orleans, LA.

Hill, J.R. (1997). Distance learning environments via the world wide web. In B. H. Khan (Ed.) *Web-Based Instruction*, Englewood Cliffs, NJ: Educational Technology Publications.

Horton, W. (2000). *Designing Web-Based Training*. New York: John Wiley & Sons, Inc.

Jacobson, M. J., Maouri, C., Punyashloke, M., & Christopher, K. (1995). Learning with hypertext learning environments: Theory, design, and research. *Journal of Educational Multimedia and Hypermedia*, *4(4)*, 321-364.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: Am empirical investigation. *Journal of Educational Computing Research*, *12(5)*, 301 - 333.

Johnson, P.J., Goldsmith, T.E., & Teague, K.W. (1995). Similarity, structure, and knowledge: A representational approach to assessment. In P.E. Nichols and S.F. Chipman (Eds.) *Cognitively diagnostic assessment*. (pp. 221-249). Hillsdale, NJ, USA: Lawrence Erlbaum Associates, Inc.

Jones, M.G. & Farquhar, J.D. (1997). User interface design for web-based instruction. In B. H. Khan (Ed.) *Web-Based Instruction*, Englewood Cliffs, NJ: Educational Technology Publications.

Lanza, A. & Roselli, T. (1991). Effects of the hypertextual approach versus the structured approach on active and passive learners. *Journal of Computer-Based Instruction*, *18*, 48-50.

Large, A. (1996). Hypertext instructional programs and learner control: a research review. *Education for Information*, *14*, 96-106.

Moreno, R. & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology*, *92(1)*, 117-125.

Nielsen, J. (2000). *Designing web usability: The practice of simplicit*y. Indianapolis, IN: New Riders Publishing.

Nielsen, J. (1996). Top ten mistakes in web design. *Alertbox*, *5*. Retrieved May 23, 2000 from the World Wide Web: http://www.useit.com/alertbox/9605.html

Nielsen, J. & Lyngbaek, U. (1990). Two field studies of hypermedia usability. in C. Green & R. McAleese (Eds.), *Hypertext: Theory into practice II*. Intellectual Press.

Niemiec, R.P., Sikorski, C., Walberg, H.J. (1996). Learner-control effects: A review of reviews and a meta-analysis. *Journal of Educational Computing Research*, *15*, 157 – 174.

Owston, R.D. (2000). Evaluating Web-based Learning Environments: Strategies and Insights. *CyberPsychology and Behavior*, *3(1)*.

Pittenger, D.J. (1993). The utility of the Myers-Briggs type indicator. *Review of Educational Research*, *63*, 467–488.

Royer, J., Cisero, C. & Carlo, M. (1993). Techniques and procedures for assessing cognitive skills. *Review of Educational Research*, *63*, 201 – 243.

Reeves, T.C. & Reeves, P.M. (1997). Effective dimensions of interactive learning on the world wide web. In B. H. Khan (Ed.) *Web-Based Instruction*, Englewood Cliffs, NJ: Educational Technology Publications.

Schank, R.C. & Cleary, C. (1995). *Engines for education*. Mahawah, NJ: Lawrence Erlbaum.

Schneiderman, B. & Kearsley, G. (1987). User interface design for the hyperties electronic encyclopedia. *Proceedings 1st ACM Conference on Hypertext*, 184 – 194.

Schvaneveldt, R.W. (1990). *Pathfinder associative networks: Studies in knowledge organization*. Norwood, New Jersey: Ablex Publishing Corp.

Shin, E. Schallert, D., & Savenye, C. (1994). Effects of learner control, advisement, and prior knowledge on young students' learning in a hypertext environment. *Educational Technology Research and Development*, *42*, 33 - 46.

Shotsberger, P. G. (1996). Instructional uses of the world wide web: Exemplars and precautions. *Educational Technology*, *36(2),* 47-50.

Smith, P.A., Newman, I.A., & Parks, L.M. (1997). Virtual hierarchies and virtual networks: Some lessons from hypermedia usability research applied to the World Wide Web. *Journal of Human-Computer Studies*, *47*, 67 – 95.

Smith, S.G. & Jones, L.L. (1989). Images, imagination, and chemical reality. *Journal of Chemical Education*, *66*, 8-11.

Sternberg, R. (1997). *Thinking Styles*. Cambridge University Press.

Young, F.L. & Watkins, S.E. (1997, April). *Electronic communication for educational and student organizations using the world wide web*. Paper presented at the annual Midwest Section Conference of the American Society for Engineering Education, Columbia, MO.

Watkins, S., Belarbi, A., Chandrashekhara, K., Hall, R.H., & Nanni, A. (1998). *Advanced Materials for Civil Infrastructures: Multidisciplinary Curriculum Development*. Project Funded by the National Science Foundation. Retrieved May, 23, 2000 from the World Wide Web: http://www.umr.edu/~smarteng

Table 1. Learning Goal, Scenario, and Problem for the Cognitive Dissonance Module in the PsychConnections Project

Learning Goals:

- Student should be able to do each of the following:

  - describe cognitive dissonance theory
  - contrast cognitive dissonance and behaviorist theory
  - describe the classic cognitive dissonance experiment and how it relates to cognitive dissonance theory
  - apply all of the above to a “real life” problem.

Scenario:

- You are a sales consultant for a large car dealership and the dealership is having trouble selling cars. The owner of the company has been trying many incentive programs such as giving customers prizes just for coming to the dealership and looking at cars, and has been offering large rebates to customers who are willing to buy cars. The money for “free” prizes is draining the dealership, and the large rebates are decreasing profits.

Your assignment:

- Prepare a presentation for the car dealership owner including the following:

  - Explain cognitive dissonance theory vs. behaviorist theory, Festinger’s and Carlsmith’s classic experiment, and how this relates to the dealer’s present strategy.

  - Describe your new plan for improving sales and profits and how this relates to cognitive dissonance theory vs. behaviorist theory.

Table 2. Categories and Representative Responses to Open Ended Qualitative Questions

No, I would not have preferred a traditional lecture

Difficulty of taking notes in a traditional lecture

- … you can pay attention instead of taking notes.
- No, because then we wouldn't be sure as to what notes you wanted us to take.
- … we are able to read the lecture, review it and have more time to ask questions.

Convenience

- … web lectures … allow us to work at our own pace.
- I was able to be more independent, and teach myself the basic underlying concepts and then come to class and have those concepts related to everyday life.
- With all of my other classes, it made it easier for me to find time to study.

Nature of Class

- No way!! In a class like this, it would have been a waste of time because there is nothing that the instructor can say to make us understand the material apart from simply reading it.
- No, with this type of class, we would only be taking notes during lecture and reviewing them later.
- No – because with this kind of material (brain info) lectures would have been too dry and unmotivating – the web lectures prevented this in many ways.

Yes I would have preferred a Traditional lecture

Advantage for auditory learners

- … you can better convey the class material in speech than in writing and it is more interesting in speech.

Ability to ask questions

- … I didn't always have the opportunity to ask questions as I would've in class.

Figure Captions

Figure 1. Web Design for Learning Framework

Figure 2. Screen Shot from PsychConnections Cognitive Dissonance Module

Figure 3. Screen Shot from a Smart Engineering Project tutorial for the Sensors Background Section to support a Smart Materials and sensors class.

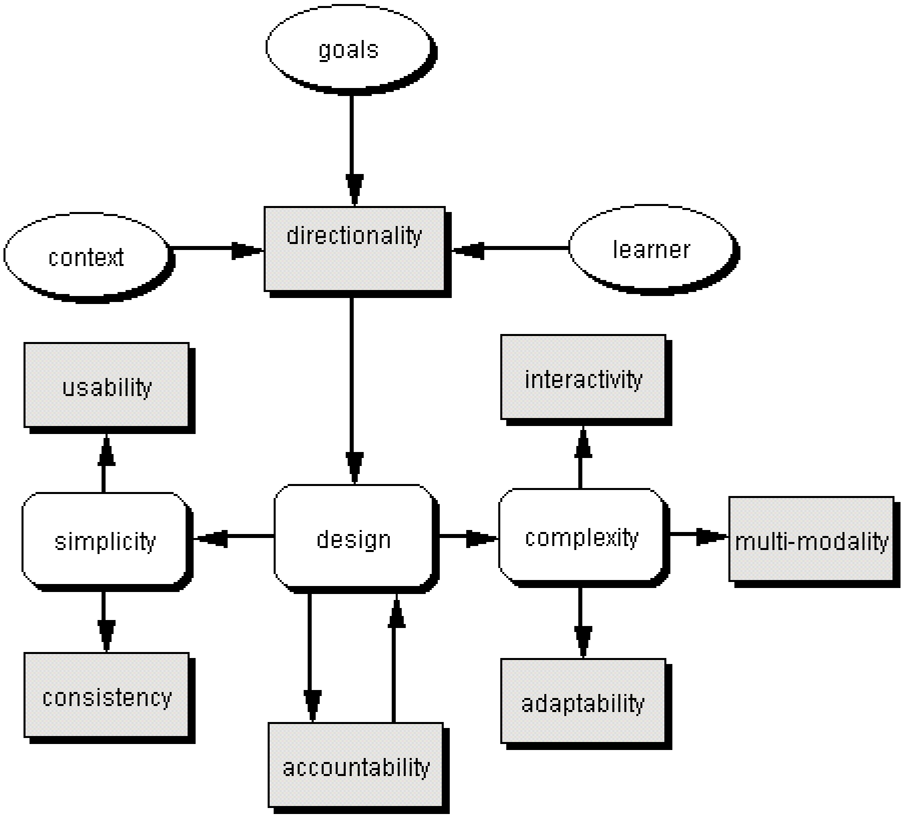
Figure 4. Screen Shot from a Best Dynamics Module on Curvilinear Motion.

Figure 5. Screen Shot from Quality Engineering Class

Figure 6. Knowledge-Based Adaptive Navigation Scheme for Prerequisite tutorials for the Sensors section of the Smart Structures and Sensors Class.

Figure 7. Prototype Assessment Model

Figure 8. Mean item Rating as a Function of Class Activity and Outcome


goals
context
directionality
learner
usability
interactivity
simplicity
design
complexity
multi-modality
consistency
accountability
adaptability

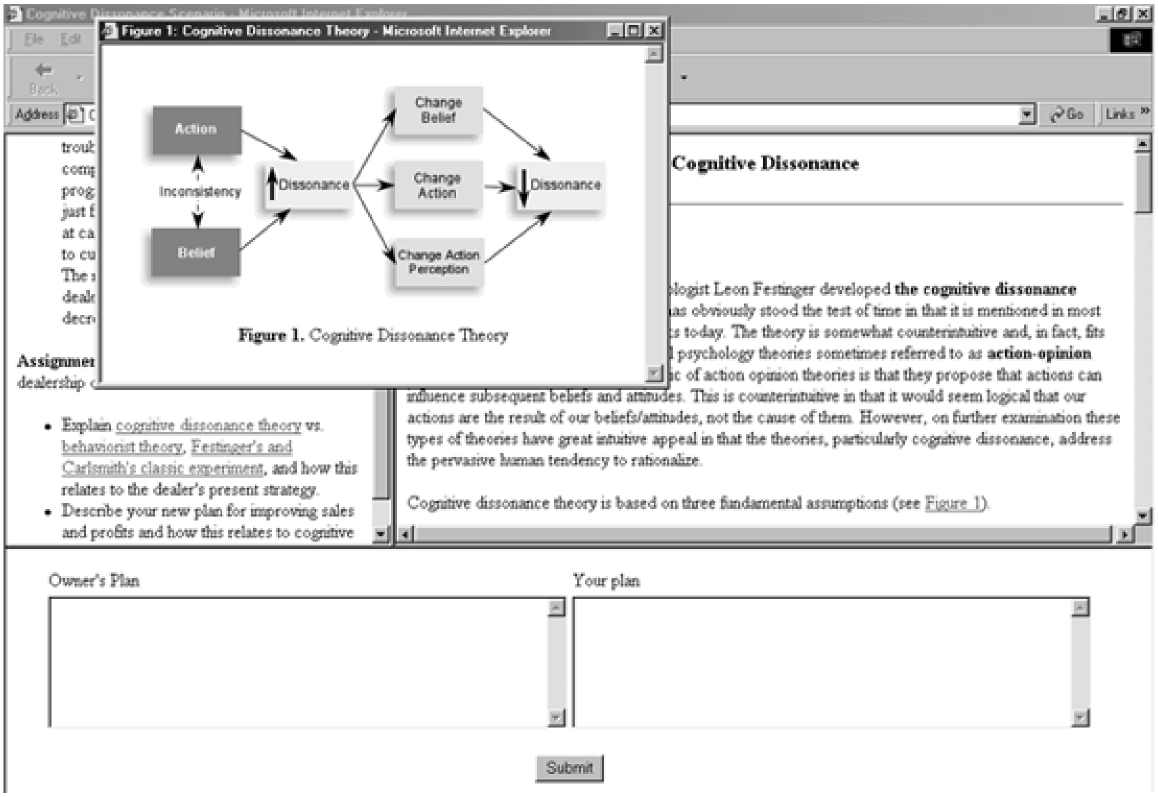


Figure 1. Cognitive Dissonance Theory

troub
comp
prog
just f
at ca
to cu
The s
deale
decr

Assignmen
dealership c

- Explain cognitive dissonance theory vs. behaviorist theory, Festinger's and Carlsmith's classic experiment, and how this relates to the dealer's present strategy.
- Describe your new plan for improving sales and profits and how this relates to cognitive

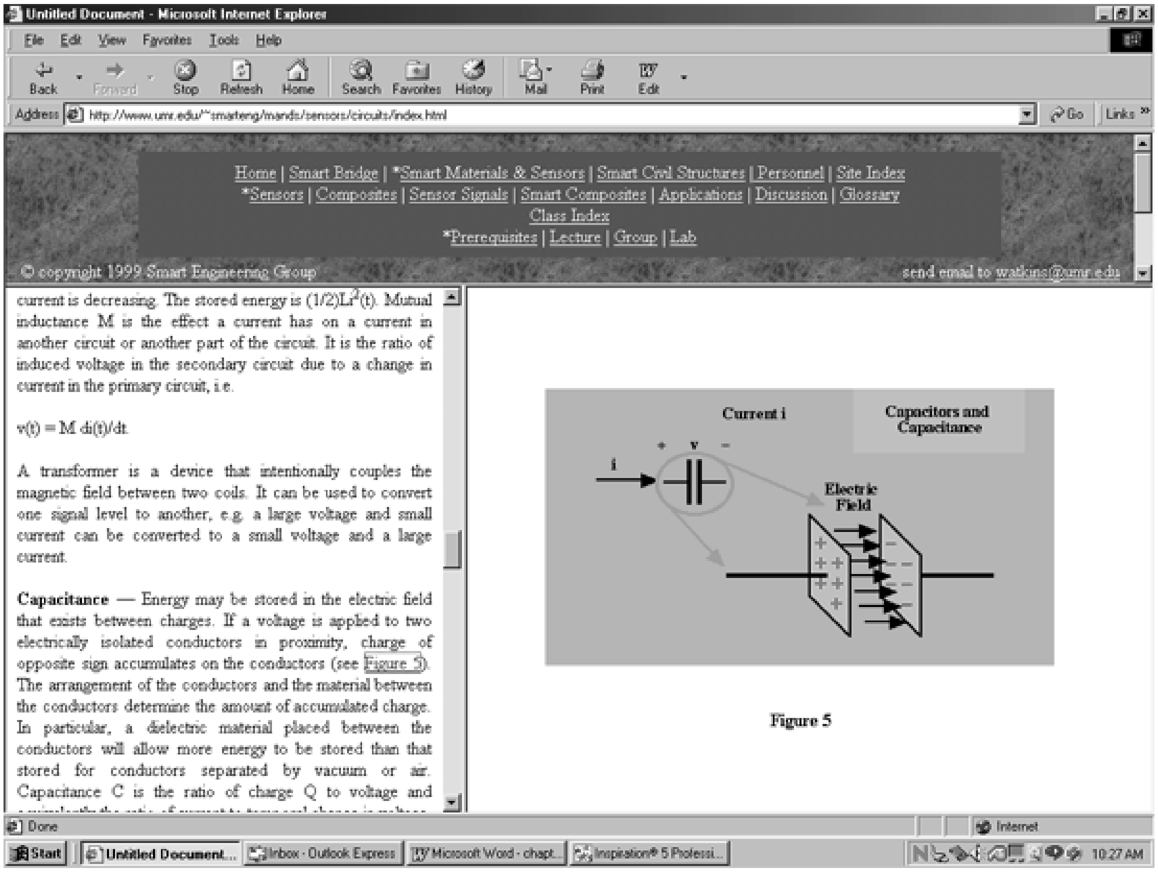
Cognitive Dissonance

logist Leon Festinger developed **the cognitive dissonance**
as obviously stood the test of time in that it is mentioned in most
s today. The theory is somewhat counterintuitive and, in fact, fits
psychology theories sometimes referred to as **action-opinion**
c of action opinion theories is that they propose that actions can
influence subsequent beliefs and attitudes. This is counterintuitive in that it would seem logical that our actions are the result of our beliefs/attitudes, not the cause of them. However, on further examination these types of theories have great intuitive appeal in that the theories, particularly cognitive dissonance, address the pervasive human tendency to rationalize.

Cognitive dissonance theory is based on three fundamental assumptions (see Figure 1).

Owner's Plan

Your plan



Home | Smart Bridge | *Smart Materials & Sensors | Smart Civil Structures | Personnel | Site Index
*Sensors | Composites | Sensor Signals | Smart Composites | Applications | Discussion | Glossary
Class Index
*Prerequisites | Lecture | Group | Lab

© copyright 1999 Smart Engineering Group

send email to watkins@umr.edu

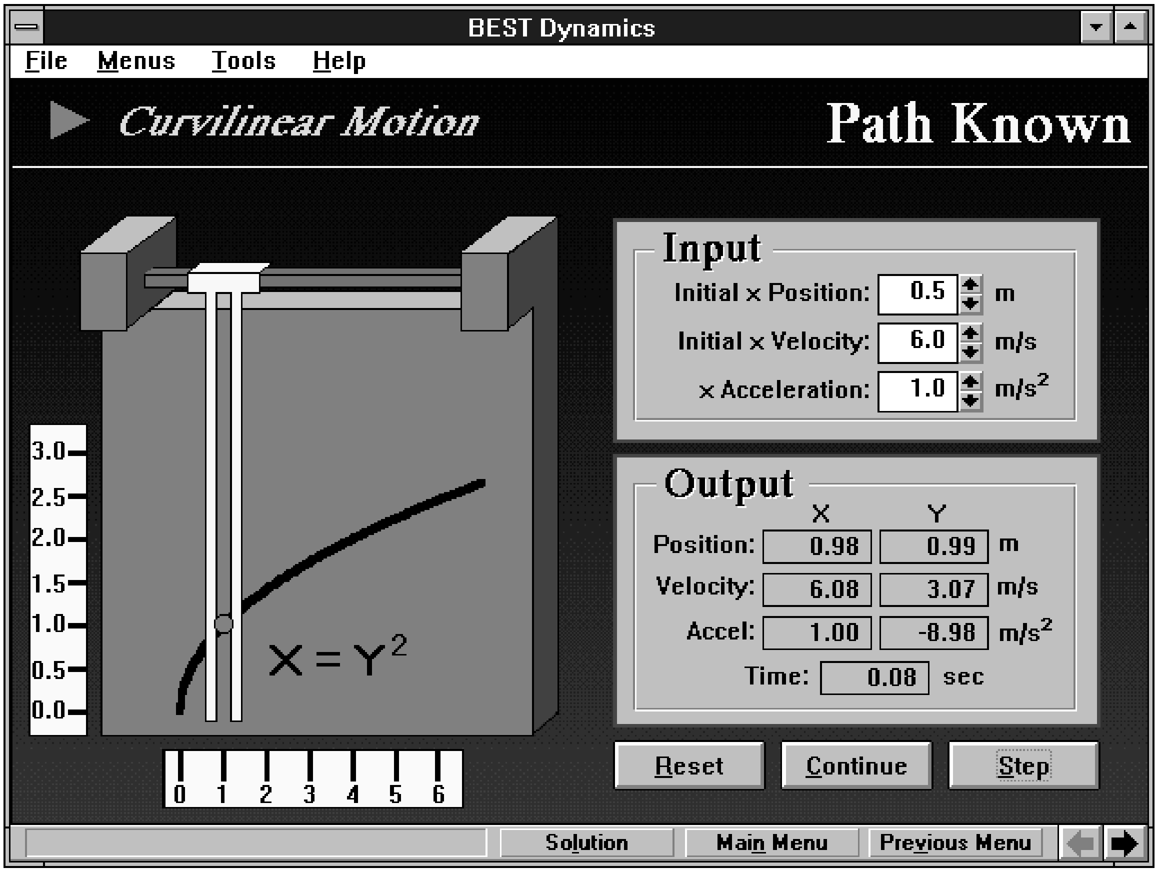
current is decreasing. The stored energy is (1/2)Li^2(t). Mutual inductance M is the effect a current has on a current in another circuit or another part of the circuit. It is the ratio of induced voltage in the secondary circuit due to a change in current in the primary circuit, i.e.

v(t) = M di(t)/dt.

A transformer is a device that intentionally couples the magnetic field between two coils. It can be used to convert one signal level to another, e.g. a large voltage and small current can be converted to a small voltage and a large current.

Capacitance — Energy may be stored in the electric field that exists between charges. If a voltage is applied to two electrically isolated conductors in proximity, charge of opposite sign accumulates on the conductors (see Figure 5). The arrangement of the conductors and the material between the conductors determine the amount of accumulated charge. In particular, a dielectric material placed between the conductors will allow more energy to be stored than that stored for conductors separated by vacuum or air. Capacitance C is the ratio of charge Q to voltage and

Figure 5



Input

Initial x Position: 0.5 m

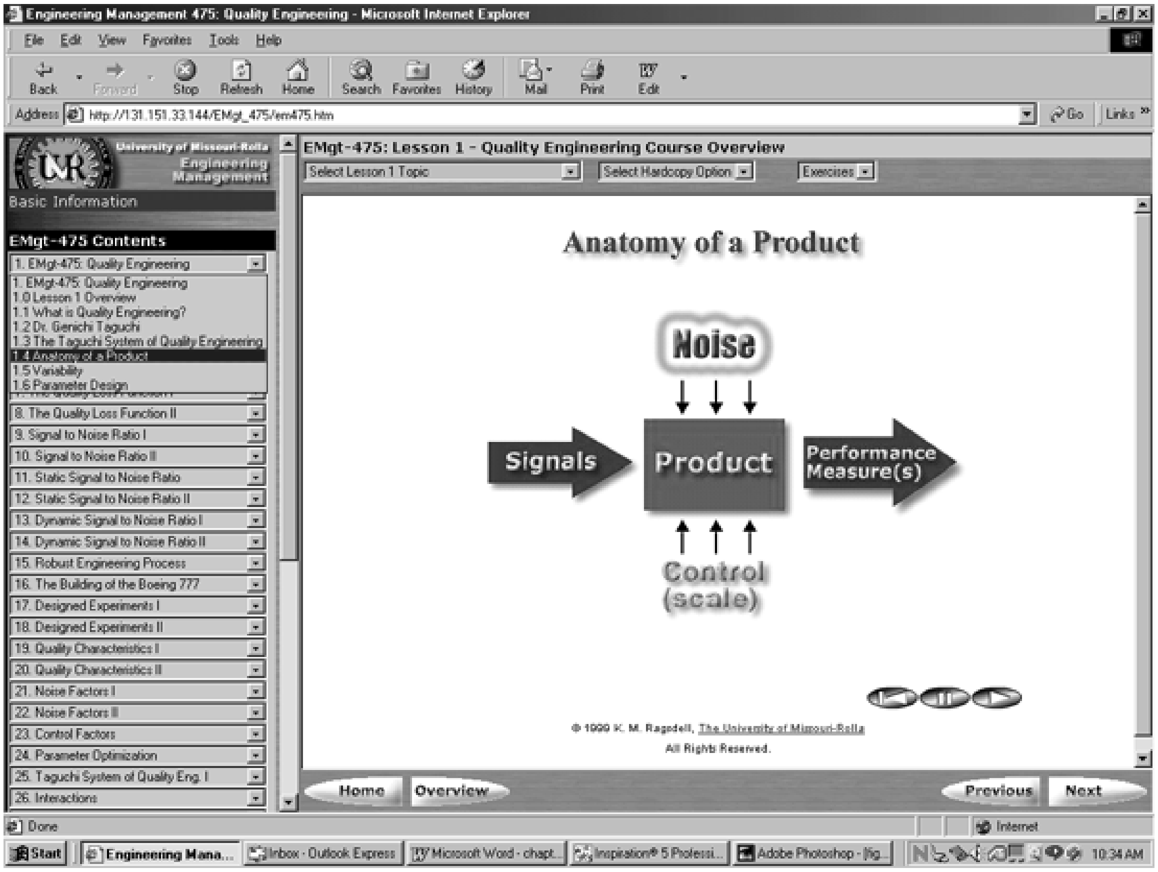
Initial x Velocity: 6.0 m/s

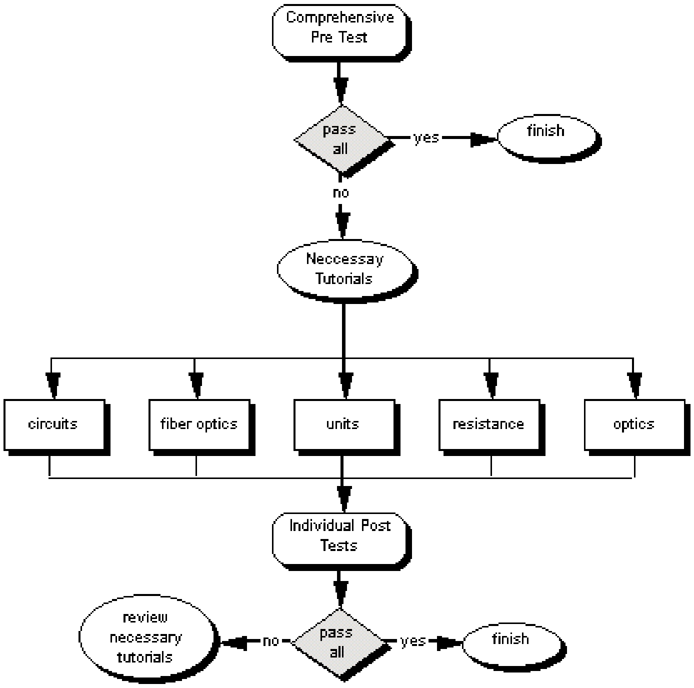
x Acceleration: 1.0 m/s^2

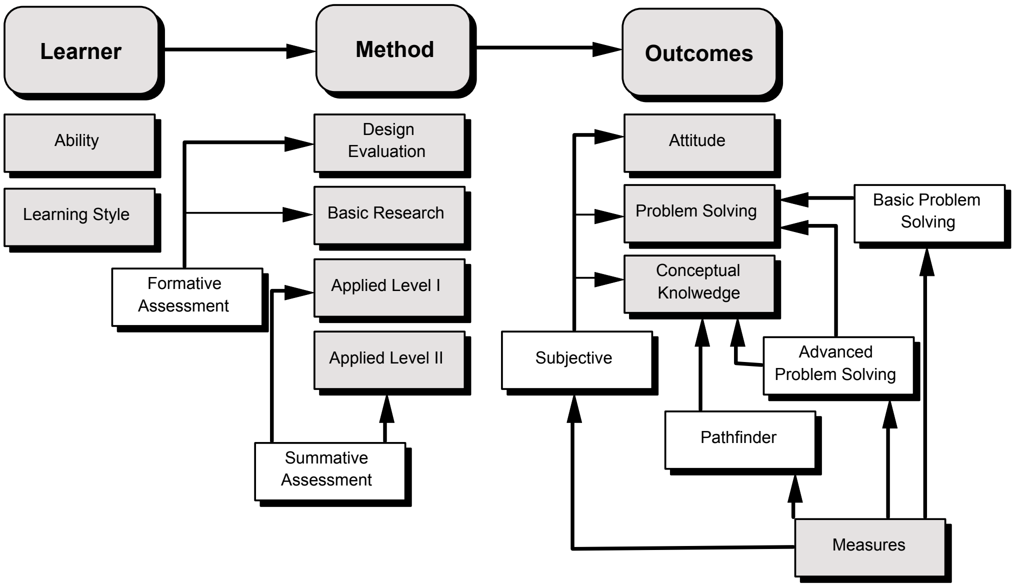
Output

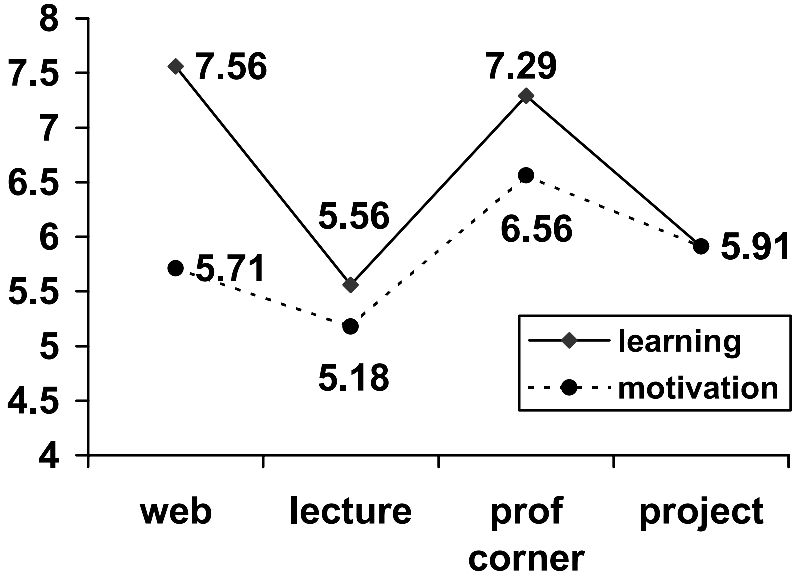
	X	Y	
Position:	0.98	0.99	m
Velocity:	6.08	3.07	m/s
Accel:	1.00	-8.98	m/s^2

Time: 0.08 sec


Engineering Management 475: Quality Engineering - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Forward Stop Refresh Home Search Favorites History Mail Print Edit
Address http://131.151.33.144/EMgt_475/em475.htm
Go Links
University of Missouri-Rolla
Engineering Management
Basic Information
EMgt-475 Contents
1. EMgt-475: Quality Engineering
1. EMgt-475: Quality Engineering
1.0 Lesson 1 Overview
1.1 What is Quality Engineering?
1.2 Dr. Genichi Taguchi
1.3 The Taguchi System of Quality Engineering
1.4 Anatomy of a Product
1.5 Variability
1.6 Parameter Design
8. The Quality Loss Function II
9. Signal to Noise Ratio I
10. Signal to Noise Ratio II
11. Static Signal to Noise Ratio
12. Static Signal to Noise Ratio II
13. Dynamic Signal to Noise Ratio I
14. Dynamic Signal to Noise Ratio II
15. Robust Engineering Process
16. The Building of the Boeing 777
17. Designed Experiments I
18. Designed Experiments II
19. Quality Characteristics I
20. Quality Characteristics II
21. Noise Factors I
22. Noise Factors II
23. Control Factors
24. Parameter Optimization
25. Taguchi System of Quality Eng. I
26. Interactions
EMgt-475: Lesson 1 - Quality Engineering Course Overview
Select Lesson 1 Topic
Select Hardcopy Option
Exercises
Anatomy of a Product
Noise
Signals
Product
Performance Measure(s)
Control (scale)
© 1999 K. M. Ragsdell, The University of Missouri-Rolla
All Rights Reserved.
Home
Overview
Previous
Next
Done
Internet
Start
Engineering Mana...
Inbox - Outlook Express
Microsoft Word - chapt...
Inspiration® 5 Professi...
Adobe Photoshop - [fig...
10:34 AM


Comprehensive Pre Test
pass all
yes
finish
no
Neccessay Tutorials
circuits
fiber optics
units
resistance
optics
Individual Post Tests
review necessary tutorials
no
pass all
yes
finish


Learner
Method
Outcomes
Ability
Learning Style
Design Evaluation
Basic Research
Applied Level I
Applied Level II
Formative Assessment
Summative Assessment
Attitude
Problem Solving
Conceptual Knolwedge
Basic Problem Solving
Advanced Problem Solving
Subjective
Pathfinder
Measures


8
7.5
7
6.5
6
5.5
5
4.5
4
7.56
7.29
5.56
6.56
5.71
5.91
5.18
learning
motivation
web
lecture
prof corner
project