Effect of learning styles on the navigational needs of Computer-Based Training module learners

Jens O. Liegle
Computer Information Systems Department - Georgia State University
Atlanta, GA 30302
jliegle@gsu.edu

Thomas N. Janicki
Information Systems Dept - University of North Carolina - Wilmington
Wilmington, NC 28403
janickit@uncwil.edu

Abstract

Web-based training with all its potential benefits is growing at a tremendous rate; however, nearly all-current systems provide a "one-size-fits-all" approach to the delivery of the material. Two approaches that try to improve end-user training have emerged in the area of software training research: adaptation of the training material content and adaptation of the training material presentation mode. Here, two modes have been discussed in the literature: learner control vs. system control. So far, no clear answer to the question which presentation mode should be used – and for whom – has been found. However, if the amount of learning is indeed dependent on the training material presentation mode and the learning style of the users, then more effective systems that adapt to this relationship could be developed.

This paper analyzes the results of an experiment completed by 58 subjects that first measured their learning style preferences (using the Kolb Learning Style Inventory Tool) and compared it to their actual usage of linked web-pages. The study found that learners classified as "Explorers" tended to "jump" more create their own path of learning, while subjects classified as "Observers" tended to follow the suggested path by clicking on the "Next" button. In addition, test scores for explorers who did jump were higher then explorers who did not jump, while conversely observers who did not jump scored higher then observers who did jump.

Keywords: Computer assisted instruction, computer-based training, web-based training, course authoring tools

1. INTRODUCTION

Background

Computer-Based Training (CBT) and its newer complement Web-Based Training (WBT) are growing rapidly. Academics are placing more course material on-line to supplement their classroom instructions. In addition, web-based training is the fastest growing method for delivering training content (McGee, 1998). However course management tools like Web-CT and BlackBoard as well as authoring tools like Authorware and Director provide a general 'one size fits all' approach and do not take into account the needs of different learners (Janicki and Liegle, 2001A) which could be a reason for the lack of success of many of these systems (Martinson and Schindler, 1995).

Therefore, there is a need to provide more customized learning modules to differing types of learners. Current technologies provide new opportunities for customized training. Two approaches that try to improve end-user training have emerged in the area of software training research (Olfman & Mandviwalla, 1994): 1) adaptation of the training material content to target learner markets and 2) adaptation of the training material presentation (order and style of presentation).

Further examining the second mode of adaptation mentioned above, Bernstein (1998) found that two different pedagogical approaches to lesson sequencing (the order and style of presentation) may work well on the Web. These pedagogical approaches are the behaviorist learning / teaching style and the constructivist theory (Bernstein, 1998; Brandt, 1997). The former guides a student through predefined steps, and the latter provides all the resources and lets students construct knowledge themselves. A variation of the learner-controlled approach in recent studies involving computer-delivered instruction has been to allow each learner to add or delete elements of instruction at frequent choice points as he or she works through the instructional program (Schnackenberg, Sullivan, Leader, & Jones, 1998).

The literature has not yet found an answer on which mode is superior. An overview of the research on learner- vs. system-control was presented by Schnackenberg et al. (1998). They found that some arguments in favor of learner-control are that 1) learners know their own instructional needs best, 2) learner-control can help students become independent learners, and 3) learners construct their own knowledge in the context of their own needs and experiences and require control over the learning process to do so (Schnackenberg et al., 1998).

Critics claim that that learner-control distracts learners because it forces them to interrupt their learning and pay attention to the sequencing of material. Others claim that beginners are unable to make the right sequence choices: “students cannot be expected to select learning tasks and topics efficiently in domains they are just beginning to learn about” (Murray, 1998). This view is supported by Lieberman and Lynn (1991) who reviewed the literature of learner- vs. system-control and found that novices should benefit from system-control, but more advanced students could benefit from learner-control. Others go even further claiming that the degree of learner-control should depend on the learner’s familiarity with the topic as well as the learner’s motivation, aptitude, and attitude (Merrill, Li, & Jones, 1992).

One such experiment was conducted by Melara (1996), who examined the effect of learning style (based on Kolb’s Learning Style Inventory) on learner performance within two different hypertext structures: hierarchical and network. Her experiment showed no significant differences in achievement for Explorers and Observers using either hypertext structure. She raises the following point: contrary to Observers, Explorers are expected to prefer experimentation over observation. Studies are needed that examine the time spent on different activities that are targeted towards these two different personality types (Melara, 1996).

The objective of this research proposal is to answer the question raised by Melara (1996) of whether the learning styles Explorer vs. Observer, as measured by Kolb’s Learning Style Inventory, have an effect on the navigational habits of users of computer-based training modules and also on the amount of learning that takes place. If this was indeed the case, developers of computer based training systems and especially web-based training systems should determine the learning style of their users first and then have two versions of their system ready for their users: one that supports exploring and one that guides the user through the material.

2. CHALLENGES FOR RESEARCHERS

a) Content Related Adaptation

There are known methodology problems with content-related research. Lieberman and Linn (1991) indicated that studies comparing classroom instruction to computer-assisted instruction (CAI) have many inherent problems. Preparation time and effort are difficult to control, content quality and instructional are delivery difficult to measure, and CAI systems suffer from a novelty effect. These factors make any comparison between human instructors and CAI systems complex.

Another approach to content-related research is the preparation of two different lesson versions that are taught by the same CAI system. However, any comparison between the learning outcome would not be conclusive since one of the major difficulties with research that compares the effectiveness of any method of presentation to another mode of presentation has been that the comparison is meaningless if the actual content of the lessons is different (McGrath, 1992).

In order to test the effectiveness of adapting the content to the preferred learning style of a user, experiments should be conducted that vary the sequence of the content within a lesson. This would change the relative emphasis on the different lesson parts but still teach the same content to all learners. To address this issue, our study used consistent learning content for the experiment between students (Janicki and Liegle, 2001B).

b) Presentation Mode Adaptation

The research on learner control is not conclusive: Schröder, Möbus, and Pitschke (1995) found that novice learners used a fairly passive strategy for moving through a hypermedia system, not utilizing their selection control and instead following a linear viewing pattern. On the other hand, Rieman, Young, and Howes (1996) showed in their experiments that learners did not follow a linear viewing pattern when they had full control; instead, no specific sequence was followed in what they call exploratory learning. Similarly, Melara (1996) found no performance differences when students used a hierarchical organized system compared to a network structure. Goforth (1994) and Tennyson (1981) found that learner control is more effective than system-control, but Young (1996) supported this finding only

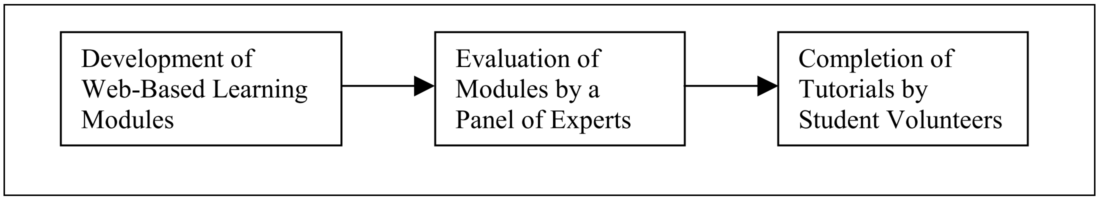

Figure 1. Experiment Design

for learners with high self-regulated learning strategies, not for others. Allinson (1992) reported in her study that some subjects used a more linear navigation approach, and others preferred self-determined hypertext navigation. Based on this discussion, the research on the effectiveness of learner- vs. system-control seems to be inconclusive at best.

It might be the case that the two approaches, learner-control and system-control, work well for different students, but at this point, the research regarding the optimal balance of learner- vs. system-control is inconclusive. It would appear that the best system would adapt itself to the learner by providing both the behavioralist and the constructivist approach based on the learner's preference and personality type (Tan, 1996). One should therefore examine the effect of the Explorer vs. Observer personality-type dimension on system- vs. learner-controlled navigation. Our study is consequently trying to provide some insight into the relationship of navigational behavior and learning style, which can in turn be used to construct more effective training systems.

3. EXPERIMENTAL DESIGN

In order to determine whether the users' learning style has an effect on their navigational needs, this study used data from a lab experiment with student volunteers. This experiment had three basic phases as shown in Figure One. Phase One involved the building of web-based learning tutorials. Ten different Ph.D. graduate business students were recruited to develop web-based tutorials based on a management theory of employee motivation.

In phase two, a panel of experts from a graduate school of education was surveyed to determine if learning concepts were employed in the design of the learning modules. The survey results indicate that the learning modules did promote the inclusion of five learning principles. These learning principles are a listing of learning objectives, list of pre-requisites, a variety of presentation styles, learner self-control through the lesson and feedback and testing. These principles were chosen as they repeatedly surface in the research to consider when building effective instructional design (Gagne, Briggs & Wager, 1988; Dear, 1987; Hannafin & Peck , 1988; Merrill, 1997; Janicki & Liegle, 2001A). These modules permitted the learning to learn new materials based on three different learning styles. These styles were: a) list the information in a narrative format; b) show the new information through an example; and c) have the learner do an exercise.

Once the graduate students developed the tutorials, a pilot test was conducted. This pilot test demonstrated that the system had been programmed effectively and could support sixteen users simultaneously without any difficulties or degradation of speed and performance. Finally the experiment was ready for testing by actual learners in phase 3 as shown in Figure 1.

Undergraduate volunteers were recruited from three sections of the same class (Principles of Management) offered during the same semester. Three different instructors taught the sections, and all instructors agreed not to present any course material on the employee motivation theories (the tutorial topics chosen for development) prior to the actual experiment. The three sections had a total enrollment of 75 subjects, with 68 students in class on the day of the experiment. Sixty-three of the students agreed to participate in the experiment. Five students were used as 'control' subjects and did not access the learning modules that were built, they 'surfed' the web for the topics related to the new course material.

A computer laboratory was reserved for each of the experimental sessions to reduce outside noise and interference. Subjects were permitted to take notes during the reading and review of the web-based materials (lesson), but were not allowed any other outside materials such as textbooks or class notes. Figure 2 below expands the third phase shown in Figure 1. Subjects were requested to complete all three steps of the experiment. The first step was completion of the survey that measures their preferred learning styles using an online version of Kolb's Learning Style Inventory (Kolb, 1976; Romero et al., 1992).

In step two the learners navigated through the actual learning content. Each web page offered the learner the option to click the "Next" button or they could have chosen to "Jump" to a different link via a "hyper linked" Table of Contents that was presented on the web-page. Finally, the subjects completed an on-line quiz.

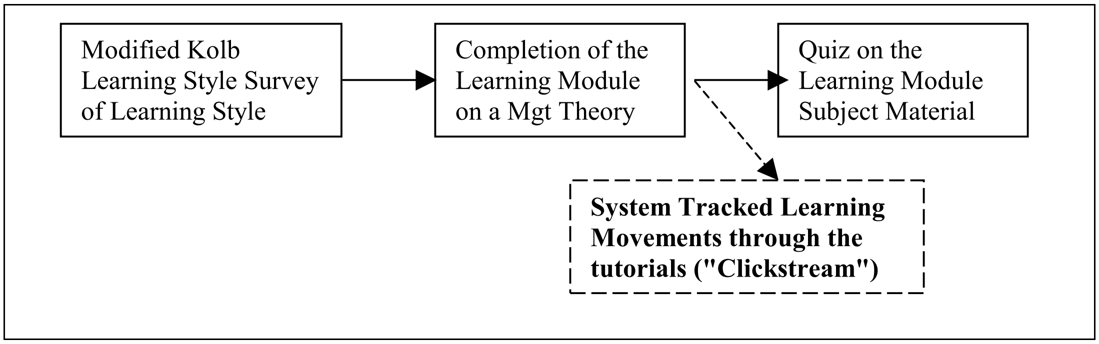

Figure 2. Subjects complete the Learning Modules (Phase 3)

The navigational behavior ("clickstream") of 58 students was logged on a page-by-page basis. "Clickstream" analysis can be used to determine the navigational behavior of the learner (Mandese, 1995; Brodwin, O'Connell, and Valdmanis, 1995). This type of analysis identifies the actual paths that the learners used and classifies them according to their degree of linearity.

4. RESULTS

This experimental research project is designed to answer the following questions:

Do learners with different learning styles use computer-based training systems differently? We postulate:

H_0 There is no difference in the approaches.

H1 Users with the learning style Explorer follow a non-linear approach to learning in computer-based learning systems, while users with the learning style Observers follow a linear approach.

Should the previous hypotheses be supported, does this have an effect on the amount of learning that takes place? We postulate:

H_0 There is no difference in the amount of learning.

H_1 a)Users with the learning style Explorer that follow a non-linear approach to learning in computer-based learning systems learn more than Explorers that follow a linear learning approach, while b) users with the learning style Observers learn more following a linear approach instead of a non-linear learning approach.

If either of the above H_1 is indeed the case, developers of computer-based learning systems should adapt the sequencing of their training material to the learning style of the user to make their systems more effective. Should neither be the case, the study might still give some insight whether a linear or a non-linear version of the modules should be used in general to achieve a higher learning outcome.

A total of 58 complete datasets were analyzed. In order to test our first hypothesis on whether the learning style had an impact on the navigational behavior, we computed the average number of out-of-sequence jumps each user made while using the learning module. We define an out-of-sequence jump (or just "jump") as a click on a link that is different from the "next" suggested link, which would lead to the web page following the current slide based on the instructors' original sequence. In addition a "jump" was not counted if a subject 're-clicked' on a link that would have taken them to the same page currently on the screen.

We further classified students into being either of personality type "observer" or "explorer" based on the Kolb Learning Style inventory questionnaire that we administered prior to the experiment. There were more than twice as many explorers than observers, which is consistent to the results of a previous experiment that we conducted (Liegle, 1999). Table 1 shows the average number of jumps grouped by personality type.

Table 1: Two sample T-Test and confidence interval of average number of jumps based on personality type

Personality Type	N	Mean	Std Dev	SE Mean	95% CI
Observer	15	0.93	1.87	0.48	(0.62, 0.86)
Explorer	43	1.91	3.24	0.49	(0.89, 2.45)

T-Test for $\mu(0) = \mu(1)$ (vs. $<$):
T=-1.41, P=0.083 , DF = 43.

We find that explorers had indeed a higher average number of jumps (1.91) than observers (0.93) with an even higher standard deviation (3.24 vs. 1.87). To test the hypothesis that the difference of the means is statistically significant, we conducted a two sample T-test for independent samples. Since p=0.083 < α = 0.1, we reject H_0 and conclude H_1: The difference of the means is significant, and therefore explorers jumped more than observers. For all statistics, an alpha of 0.1 was used, since this is exploratory research (Bostrom, Olfman, & Sein, 1990, 1993).

To test the second hypothesis, whether the difference in jumping had an impact on the amount of learning for the two different groups, we compared the average test scores of users who jumped vs. users who did not jump. Since the average number of jumps is relatively small (Mean=1.65, St.Dev=2.96), there were not enough data points for us to compare the test scores based on the actual number of jumps. We therefore assume that users who did not jump did so because they were consciously following the "next" page approach, while users that jumped at least once were not, especially considering that the average number of pages that were available to the users was relatively small (8 per learning module). We therefore only compared users that did not jump at all to users that jumped once or more often.

We conducted independent sample t-tests for both personality types. See tables 2, 3a and 3b for the results.

Table 2: Two sample T-Test for Explorers

Jump	N	Mean Test Score	Std Dev	SE Mean
Explorers who did not Jump	23	58.0	11.8	2.5
Explorers who did Jump	20	64.3	14.6	3.3

95% CI for $\mu(0) - \mu(1)$: (-14.6, 1.9)
T-Test for $\mu(0) = \mu(1)$ (vs. <):
T=-1.56, P=0.064, DF = 36.

From Table 2, we find that explorers who did not jump had a lower mean score (58.0) than explorers that jumped (64.3). Since P=0.064 < α = 0.1, we reject H_0 and conclude H_1 and find that difference to be statistically significant.

Based on the results from Table 3a , we find that observers who did not jump had a higher mean score (61.8) than observers that jumped (48.3), which also means that jumping had the exact opposite effect on explorers than on observers. However, since P=0.16 > α = 0.1, we can not reject H_0 and must therefore conclude that the difference is statistically not significant. Still, a number of factors motivated us to take a closer look at these results: First, there were only four observers that jumped, while 11 did not jump at all. And second, while the difference of the two mean scores is actually fairly high (13.5), the main reason for this difference is being significant is the much larger standard deviation of these four users. A closer examination of these four users revealed one potential outlier: This user jumped a lot (six times, significantly above the mean of 0.93 jumps for an observer). At the same time, this user's score on the personality type scale just barely classified him/her as an observer (23 points, where any score above 24.5 would have been classified as an explorer). When we dropped this user to see if it made a difference, the score difference indeed becomes significant at p=0.089 < α = 0.1 (see Table 3b).

Table 3a: Two sample T-Test for Observers

Jump	N	Mean Test Score	Std Dev	SE Mean
Observers who did not Jump	11	61.8	10.4	3.1
Observers who did Jump	4	48.3	22.0	11

95% CI for $\mu(0) - \mu(1)$: (-22.9, 50)
T-Test $\mu(0) = \mu(1)$ (vs >):
T = 1.18 P = 0.16 DF = 3

With only four (three) observations in the last category, we do not feel comfortable to simply drop an observation, especially since our relatively small overall sample size of 58 complete records did not produce an evenly distributed number of users for the different categories. However, we see the results as basically supporting our hypothesis, and feel confident that there is indeed a relationship between the navigation mode, the learning style, and the amount of learning that took place.

Table 3b: Two sample T-Test for Observers (excludes one outlier)

Jump	N	Mean Test Score	Std Dev	SE Mean
Observers who did not Jump	11	61.8	10.4	3.1
Observers who did Jump	3	30.0	17.6	10

95% CI for $\mu(0) - \mu(1)$: (-24.0, 68)
T-Test $\mu(0) = \mu(1)$(vs >):
T = 2.05 P = 0.089 DF = 2

5. LIMITATIONS AND FUTURE RESEARCH

This study has a number of limitations. For one, while an alpha of 0.1 is sufficient for exploratory research (Bostrom et al., 1990, 1993), the differences were only significant in the p=0.08 range. Possible reasons are that the average number of pages of a training module was fairly small at an average of eight per learning module. This gave students only few choices; results might be different when students have to learn fairly large modules. The small number of pages is, however, consistent with learning theory that claims that a module should be completed within a session that should last no longer than 20 to 25 minutes as the average adult attention span is 22 minutes (Ward & Lee, 1995). The same is true for the limited time that our subjects had up to 45 minutes to complete the modules, however the average time per subject was less then 20 minutes. Longer modules, more links, and more time might lead to different results.

Another limitation was that our experiment gave *all* users the option to simply go to the next page or – at any time – to jump to an out-of-sequence page. We found that the amount of learning indeed depended on the learning style observer vs. explorer in combination with their mode of navigation. A next step would be to conduct experiments that classify users into the observer vs. explorer category and then give them customized navigation options in form of simple next button vs. hyperlink-enabled systems. We propose that explorers, when forced to constantly make a choice on where to go next, will learn more compared to explorers that can only go to the next-page. In contrast, we propose that observers that are forced to select their next page will learn less than observers that are guided through the learning material in form of sequential next-page navigation.

In addition, further research needs to be conducted that examines whether the potential increase in learning is offset by the increase in cost that comes with the need for providing multiple versions of the training system.

6. SUMMARY

This paper summarizes the results of an experiment to determine if different learners (observes versus explorers) have different navigational needs to assist them in learning. It was observed that explorers did not follow the suggested path, and they expressed a desire to "jump" around the learning modules and learn at their own sequence. It was also observed that subjects who were observers followed the suggested path of learner by clicking the "next" button.

In addition, explorers who did indeed jump scored higher on the quiz at the end of the learning module than explorers who did not jump. Conversely, observers who did not jump scored higher on the quiz at the end of the learning module then observers who did jump. Both of these findings are consistent with the theories presented by other researchers.

This research provides insights for both the academic community as well as for IS managers. For the research community, the proposed hypothesis from Tan (1996) and Melara (1996) that the amount of learning will increase when the teaching style is adapted to the learner by providing both the behavioralist and the constructivist approach to learning based on the learner's personality type was tested and principally found to be true.

For practitioners, the results of this study can have significant implications: Web-based training with all its potential benefits is growing at a tremendous rate (McGee, 1998). If, like our study shows, the amount of learning is indeed dependent on the amount of learner control and the learning style of the users, then more effective systems could be constructed that make use of this relationship.

Further research is needed to be conducted that examined whether the potential increase in learning is offset by the increase of cost that would come with the need for providing multiple versions of the training system.

7. REFERENCES

Allinson, L. (1992). Learning Styles and Computer-Based Learning Environments. 4th International Conference ICCAL '92, Wolfville, Nova Scotia, Canada.

Bernstein, D. (1998). WBT: Are We Really Teaching? Inside Technology and Training, 2, 15-17.

Bostrom, R. P., Olfman, L., & Sein, M. K. (1990). The Importance of Learning Style in End-User Training. *MIS Quarterly, 14*(2), 101-119.

Bostrom, R. P., Olfman, L., & Sein, M. K. (1993). Learning Styles and End-User Training: A First Step. *MIS Quarterly, 17*(1), 118-120.

Brodwin, D.; O'Connell, D.; Valdmanis, M.(1995). Mining the Clickstream. Upside, 101-106.

Brandt, D. S. (1997). Constructivism: Teaching for Understanding of the Internet. Communications of the ACM, 40(10), 112-117

Dear, B., (1987) AI and the Authoring Process. IEEE Expert, 2(4), 17-23.

Gagne, R.; Briggs, L. and Wager, W., (1988) Principles of Instruction Design Third Edition. New York: Holt, Reinhard, & Winston.

Goforth, D. (1994). Learner Control = Decision Making + Information. Datamation, 43(9), 96-101.

Hannafin, M. and Peck, K. (1988) The Design Development and Evaluation of Instructional Software. New York: MacMillian Publishing.

Janicki, T., Liegle, J.O. (2001A). Development and evaluation of a framework for creating web-based learning modules: a pedagogical and systems perspective, Journal of Asynchronous Learning Networks, Summer 2001.

Janicki, T., Liegle, J.O. (2001B). More than class notes? A features review of current web-based course management tools and their adherence to accepted learning pedagogy, Journal of Allied Academies, Summer 2001.

Kolb, D. (1976). Learning Style Inventory, Self-Scoring Test and Interpretation booklet. Boston, MA: McBer and Company.

Lieberman, D.A.; Linn, M.C. (1991). Learning to Learn Revisited: Computers and the Development of Self-Directed Learning Skills. Journal of Research on Computing in Education, 23(3), 373-395

Liegle, J.O.: Development and Evaluation of Intelligent Tutoring Systems for Just-in-time Learning. Dissertation at Kent State University, Kent, 1999.

McGee, M.K. (1998). Save On Training, Information Week, June, 141-146.

McGrath, D. (1992). Hypertext, CAI, Paper, or Program Control: Do Learners Benefit from Choices? Journal of Research on Computing in Education, 29(3), 276-296.

Melara, G.E. (1996). Investigating Learning Styles on Different Hypertext Environments: Hierarchical-Like and Network-Like Structures. Journal of Research on Computing in Education, 14(4), 313-328.

Mandese, J. (1995) "Clickstreams" in cyberspace, Advertising Age, 66(12), 18.

Martinson, M.G.; Schindler, F.R. (1995). Organizational Visions for Technology Assimilation: The Strategic Roads to Knowledge-Based Success. IEEE Transactions on Engineering Management, 42(1), 9-18.

Merrill, M.D (1997) On Instructional Strategies, Instructional Technology Magazine, 2(1).

Merrill, M.D.; Li, Z.; Jones, M.K. (1992). Instructional Transaction Shells: Responsibilities, Methods, and Parameters. Educational Technology, 5-26.

Murray, T. (1998). Authoring Knowledge-Based Tutors: Tools for Content, Instructional Strategy, Student Model, and Interface Design. The Journal of the Learning Sciences, 7(1), 5-64

Olfman, L.; Mandviwalla, M. (1994). Conceptual versus Procedural Software Training for Graphical User Interfaces: A Longitudinal Field Experiment. MIS Quarterly, 18(4), 405-426.

Rieman, J.; Young, R.; Howes, A. (1996) A dual-space model of iteratively deepening exploratory learning. International Journal of Human-Computer Studies, 44(6), 743-755.

Romero, J.E.; Tepper, B.J.; Tetrault, L.A. (1992). Development and Validation of New Scales to Measure Kolb's Learning Style Dimensions. Educational and Psychological Measurement, 52, 171-180.

Schnackenberg, H.L.; Sullivan, H.J.; Leader, L.F.; Jones, E.E.K. (1998). Learner Preferences and Achievement Under Different Amounts of Learner Practice. Educational Technology Research and Development, 42(2), 5-15.

Schröder, O.; Möbus, C.; Pitschke, K. (1995). A Cognitive Model of Design Processes for Modeling Distributed Systems. Conference on Artificial Intelligence in Education, Washington, D.C., August 16-19.

Tan, S.T. (1996). Architecture of a Generic Instructional Planner. Journal of Network and Computer Applications, 19, 265-274.

Tennyson, R. D. (1981). Use of Adaptive Information for Advisement in Learning Concepts and Rules Using Computer-assisted Instruction. American Educational Research Journal, 18(4), 425-438.

Ward, E. and Lee, J. (1995). An instructors guide to distance learning. *Training & Development,* 49 (11), 40-44.

Young, J.D. (1996). The Effect of Self-Regulated Learning Strategies on Performance in Learner Controlled Computer-Assisted Instruction. Educational Technology, Research and Design, 44(2), 17-27.