

## **Individualizing Instruction in a Web-Based Hypermedia Learning Environment: Nonlinearity, Advance Organizers, and Self-Regulated Learners**

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This study attempted to determine what combination of nonlinearity and advance organizers worked best for learners with given levels of self-regulation. While the results of the study showed no significant main effects or interactions, there were two near significant interactions: between nonlinearity and self-regulated learning ( $p = 0.054$ ), and between nonlinearity and advance organizers ( $p = 0.052$ ). These results strongly suggest that highly self-regulating learners learn poorly in mostly linear web-based hypermedia learning environments, where they have very few choices, while medium self-regulating learners learn poorly in highly nonlinear environments where they are given too many choices. The results also strongly suggest that advance organizers are more effective in highly nonlinear web-based hypermedia learning environments than in mostly linear environments. While not conclusive, the results of this study support further research.

Learning systems function best when they adapt to the needs of individual learners (Park & Hannafin, 1993). Technology based learning environments offer educators the ability to individualize instruction for learners consistently and automatically. To take full advantage of this ability, it is first necessary for researchers to determine which instructional strategies, or combinations of instructional strategies, work best for learners of a particular

profile. Learners derive the most benefit from a technology based learning environment when the capabilities of the environment are used to perform or model tasks that are important to learning and that the learner cannot, or does not, perform him/herself (Kozma, 1991).

Appropriate learning environments require an understanding of the learner. Learner profiles, which represent all the important characteristics that might affect how the learner interacts with a particular learning environment, may include such characteristics as the amount of prior knowledge of the learning domain, experience and facility with the learning medium, learning style, age, gender, and other characteristics. In short, a learner profile is a catalogue of all the aspects, which make one learner different from another and which can be proven relevant to learning in a particular learning environment.

Once a learner's profile is determined, computers can adapt the instructional environment to present instruction in a way that best suits that learner. Instructional strategies such as program or learner control and Socratic or Aesopic discourse can be selected. The instruction can be presented in a manner that is most suitable for the learner. Concentration on aural, visual, or haptic stimulus can be chosen, as can the proper type and amount of feedback.

A large body of research has attempted to define which individual differences actually influence learning. Numerous studies have looked at the effect of instructional strategies, but usually in isolation from each other. Even Cronbach and Snow's Aptitude Treatment Interaction studies (Cronbach & Snow, 1977; Snow, 1989) looked primarily at single strategies and characteristics. To effectively individualize instruction, it is necessary to examine the *interactions* between various learner characteristics and multiple instructional and presentation strategies, as this study has begun to do.

The learner characteristic examined in this study is self-regulated learning, a complex composite of cognitive, metacognitive, motivational, and environmental strategies and attributes. Self-regulated learners actively control the interactions between themselves, their learning, and their environment (Bandura, 1986; Schunk, 1991; Zimmerman, 1989). High self-regulating learners monitor and guide their own learning; low self-regulating learners are more motivationally and metacognitively passive in their reception of instruction. Deliberation, or intention, is a requisite component of self-regulated learning. A self-regulating learner has to be aware of his/her strategy use, and the strategy use must help him/her achieve the intended goals (Zimmerman, 1989). While there is disagreement (Sweany, McManus, Williams, & Tothero, 1996; Weinstein, Palmer, & Schulte, 1987), some researchers believe

the strategies of self-regulated learning are context-dependent (Pintrich, Smith, Garcia, & McKeachie, 1993; Williams, 1996). That is learners who regulate their own learning in some instructional environments may not be as strategic in others. Therefore, it is important when defining a learner profile to examine self-regulated learning in relation to a specific learning environment.

Web-based hypermedia learning environments allow educators to choose from numerous instructional and presentation strategies. Nonlinearity of instructional presentation and the use of advance organizers are two such strategies. Hypermedia environments allow instructors to present information in a nonlinear fashion, allowing the learner to jump freely from one idea to another, without concern for predetermined order or sequence. Thus hypermedia environments let the learner control the organization of the information, making it more personally relevant (Liu, 1992). The linked structure of hypermedia may more accurately reflect the associative network that makes up the human memory and allow a more realistic representation of expert semantic networks (Jonassen, 1993).

Another instructional strategy available in web-based hypermedia learning environments is advance organizers, which help bridge the gap between what a learner already knows and what the instruction is trying to teach. Based originally on Ausubel's Subsumption Theory (Ausubel, 1960, 1963, 1968, 1978) advance organizers are short introductory prose passages that give learners a structure for tying new information to prior knowledge (West, Farmer, & Wolff, 1991). Knowledge in an instructional environment that is consistent with prior knowledge activated by the advance organizer is assimilated into the activated schema, while information not consistent with the schema is stored discretely. Some research shows that advance organizers can be more effective in some circumstances than in others. For instance, their effectiveness varies based on the amount of structure in instructional texts. Advance organizers seem to give learners advance warning, which may enable them to better organize the new information presented in an unstructured instructional environment (Mayer, 1978).

## RESEARCH QUESTIONS

In examining the manner in which instructional strategies and learner characteristics interact, this study attempts to answer the following seven questions:

1. Can learner self-regulation affect knowledge acquisition in a web-based hypermedia learning environment?

2. Which level of nonlinearity is most effective for promoting knowledge acquisition in a web-based hypermedia learning environment?
3. Can advance organizers improve knowledge acquisition in a web-based hypermedia learning environment?
4. Can nonlinearity affect knowledge acquisition differently for each level of learner self-regulation in a web-based hypermedia learning environment?
5. Can advance organizers improve knowledge acquisition for each level of learner self-regulation in a web-based hypermedia learning environment?
6. Is there a significant interaction between level of nonlinearity and the presence of an advance organizer in a web-based hypermedia learning environment?
7. Is there a significant interaction between level of nonlinearity and the presence of an advance organizer for each level of learner self-regulation in a web-based hypermedia learning environment?

## DESIGN

This study, a 3x3x2 ANCOVA with two co-variables, was designed to search for possible interactions between nonlinear presentation, advance organizers, and learner self-regulation in a web-based hypermedia learning environment. The following sections include descriptions of the sample, independent variables, dependent variables, concomitant variables, procedure, and analysis of data. The instructional environment for the study was *Operating Systems Basics*, a web-based tutorial on the basic functions and operations of the Windows95™ and Macintosh™ personal computer operating systems. The tutorial covered such questions as “What is a floppy disk?”, “How do I open a program?”, and “How do I rename a file?”.

The subjects were volunteers from the Computing Tools for Educators course in the College of Education of a large southwestern university. The majority of the students were undergraduate elementary education, secondary education, and kinesiology majors. This introductory level technology application and integration course is required of all education majors in the teacher preparation program. Secondary and physical education majors who have sufficient familiarity with computer operations are allowed to place out of the course if they can pass a comprehensive competency test. With many of the more experienced students testing out of the course, those students who do enroll are often novices who are completely unfamiliar with computers.

There were 159 students who went through the instruction. Of these, only 119 completed all of their evaluations. The exact demographics of the

volunteers cannot be given, as the data gathered were stripped of all identifying information except a subject number. The demographics of the classes from which the sample was taken are known. The students in the classes ranged in age from approximately 20 to 45 years of age. They were predominantly white females (approximately 65%), with a lesser number of minority females (approximately 20%). Males made up approximately 15% of the class. These percentages reflect the student demographics of the College of Education as a whole. All volunteers who completed the instruction and evaluation were included in the data analysis.

The instruction used for the study was a part of the standard curriculum for the Computing Tools for Educators course. The first topic covered in the curriculum is Macintosh™ (Mac) and Windows95™ (Win95) operating system basics. This knowledge is a prerequisite for every other application taught in the course. Until the summer of 1997 this topic had been taught using traditional lecture and demonstration techniques. There were some problems inherent to this method. As the course covers both Mac™ and Win95™ platforms, and many students have easy access to only one of those platforms, course instructors decided that a cross-platform delivery method was essential. Starting in the summer of 1997 the chief instructor, Dr. Jenny Burson, decided to try out a new delivery method, online tutorials. The needs of the students lead to the use of the Web. The Web provided the capability for learners to access the instruction from almost any location: the classroom, the computer lab, or at home. Using the Web also allowed the learners to run both the Mac™ and Win95™ tutorials from any computer with a web connection, regardless of the platform. Thus was developed a web-based hypermedia learning environment called *Operating System Basics*. The instructional objectives of *Operating System Basics* were based on the same objectives as the classroom-based version of the instruction. There were two basic sub-sets of objectives: declarative knowledge, such as “What is a hard drive?” and procedural skills, such as “How do you save a file?” For the purpose of the course the student’s achievement of these objectives was evaluated by the completion of a set of tasks, turned in two weeks after the instruction was completed. As this two-week period between instruction and evaluation allowed for numerous influences other than the instruction to affect the learners’ performance, the evaluation of learner achievement for the study was separate from the course evaluation. It was completed within a week of the instruction. The evaluation measure used will be described in detail in the dependent variable section.

## NONLINEARITY OF INSTRUCTIONAL PRESENTATION

**Table 1**  
Levels of Nonlinearity

Level	Level 1— Linear	Level 2— Browsable	Level 3— Linked	Level 4— Searchable	Level 5 — Interconnected
<b>Options</b>	8. a pre-defined beginning, middle, and end 9. can only be navigated from the beginning to the end	1. a pre-defined beginning, middle, and end 2. can start, stop, review, go forward, go backward, or skip to the end.	<ul style="list-style-type: none"> <li>● no pre-defined beginning, middle, and end</li> <li>● can navigate using a menu to select nodes</li> <li>● each node is linear</li> </ul>	<ul style="list-style-type: none"> <li>● no pre-defined beginning, middle, and end</li> <li>● can navigate using a menu</li> <li>● can navigate w/keyword searches</li> </ul>	<ul style="list-style-type: none"> <li>● no pre-defined beginning, middle, and end</li> <li>● can navigate using a menu</li> <li>● can navigate w/keyword searches</li> </ul>
<b>Examples</b>	radio, TV, films	books, videotapes, videodisks	menu based hypermedia, many web sites	multimedia encyclopedias	some computer help documents

Nonlinearity is one of the basic traits of hypermedia learning environments, including web-based hypermedia environments. If this processing characteristic is removed from a hypermedia environment it becomes, in effect, a different medium. Therefore, in order to examine the effect of nonlinearity on learner achievement in a hypermedia environment, it is necessary to compare treatments that have different levels of nonlinearity rather than comparing linear and nonlinear treatments. If different levels of nonlinearity are to be compared, they first must be defined. Prior to the study, five levels of nonlinearity were defined, each describing points on a continuum. These levels are, one through five: linear, browseable, linked, searchable, and interconnected. These levels indicate the number and type of options available to the learner within the given instructional module. They reflect the capabilities of the environment rather than the type of links or the actual navigation patterns of the learner. Since nonlinearity is a characteristic shared by media other than hypermedia, it is necessary to define these levels in such a way as to be applicable to all media.

The first level of nonlinear presentation is linear. These presentations have a pre-defined beginning, middle, and end. The presentation can only be

navigated from the beginning to the end. The only other choice or control the learner has is to end the presentation. Examples of this type of presentation would include radio or TV broadcasts and films where the learner does not have access to the projector. Learners can only passively receive the information being presented, with the only option available is to turn off the radio or walk out of the movie theater. This level may not be possible in web-based environments as the learner can always enter a different URL in the browser and go to a different page, if she knows the location of that page.

The second level is a browseable presentation. Like level one presentations, level two presentations have a predefined beginning, middle, and end. But the learner has more control over the pacing of the presentation. The learner can start, stop, review, go forward, go backward, or skip to the end. Examples of this level of nonlinearity include environments. This level has no learner controls other than back and forward, stop and start. But even these simple controls allow the learner to review information, if not reorganize it. The designer is able to specify the order in which the information will be presented, though the learner can change the starting point to a certain extent.

The third level is a linked presentation. Level three presentations have no predefined beginning, middle, and end. Learners can navigate to a number of select entry points (nodes) for the presentation, but each node is linear from that point. Examples include menu-based hypermedia environments, including many web sites. Learners are presented with a menu at the start of the program from which they can access various sections of the presentation. This level allows the designer to chart specific pathways through the instruction. The learner has the ability to sequence the paths but not to change them. There is no search tool, so the learner cannot access the information in any ways other than those provided by the designer.

The fourth level is a searchable presentation. Level four presentations also have no predefined beginning, middle, and end. Learners can navigate using a menu. But the learner can also navigate to any point within the presentation through keyword searches. The addition of a search tool allows a learner to exert greater control over access to the information. At this level the order in which the information is presented within the area accessed by the learner is still the same, and the learner still has the option to follow the preset paths through the instruction. But if he/she is interested in a particular topic not available on the menu, he/she can search to find it. A common example of this type of presentation is the multimedia encyclopedia. Learners can choose from the menu options or search for articles based on keywords. But within the articles, the information is still presented linearly.

The fifth level is an interconnected presentation. Like level four presentations, level five programs have keyword searches that allow the learner to access any portion of the instruction at will and menus which provide numerous starting points, but they add hyperlinks within the instruction which show designer-provided connections. Each discrete chunk of information can be used to navigate to a pertinent related point within the presentation. These links allow the designer to provide paths to particular places in the instructional landscape, at the same time allowing the learner to control their own progress and navigate to any point in the environment. This level of nonlinearity is rarely seen. A common example that approaches this level is some computer help documents. They have a menu to start the user and allow keyword searches. Each page is made up of a short text piece with links to other relevant pages. In some cases every word leads to another node.

In the study, three different nonlinear presentations were created. The content was the same for all three levels, only the way they were organized and presented was different. For the purposes of this study, three levels of nonlinearity were chosen. As stated before, level one nonlinearity is not a characteristic of true hypermedia environments, therefore it was not chosen. Level two nonlinearity is as linear as true hypermedia gets, so it was chosen to represent one end of the comparison. Level five nonlinearity represents the other end of the scale. To fine tune the comparison, a medium level, level three, where the learner is given real responsibility for organizing the information, was chosen.

### **Advance Organizers**

The second treatment variable was the presence or absence of advance organizers. The organizers were short prose paragraphs that introduced substantial new information and linked the upcoming lesson to preexisting knowledge structures. Half of the instructional environments had advance organizers. Half did not. In the treatments with advance organizers, the organizers preceded each section of the lesson. For instance, in the lesson about renaming folders in Windows95™, before the learner got to the actual instruction he/she was presented with the advance organizer for that lesson. These advance organizers attempted to tie the material about to be presented to prior knowledge from earlier in the instruction and knowledge of the world in general. An example of an advance organizer from the instruction:

It is important to remember the basic parts of a computer command when trying to rename a folder or file. The action is rename. The object is the file or folder you want to rename. And the location, in this case, is the same as the object. Just as you would rename a folder in the real world, on the computer you rename a folder by selecting it and typing the new name on the label.

### Self-Regulated Learning

The classification variable in this study was learner self-regulation as measured by the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & Garcia, 1991). The MSLQ was designed as a paper and pencil test. It could be given either as a whole, with questions measuring 17 different constructs, or each scale could be given separately to measure particular constructs. It was also designed to be given in a particular class. For this study five scales: those dealing with Metacognitive Self-Regulation, Organization, Elaboration, Self-Efficacy, and Control Beliefs, have been extracted from the others and revised to reflect the hypermedia environment. These particular scales were chosen because they test for those self-regulatory strategies which might apply to a short, hypermedia based learning environment. Other scales such as Peer Learning, Help Seeking, and Time and Study Environment, by definition (Pintrich, Smith, Garcia, & McKeachie, 1993) measure strategies which are less likely to be used in a learning environment such as the *Operating System Basics* tutorial.

The revised questions were similar in all ways to the original, except that the words “this class” or “this course” were, in some cases, replaced with “this program” or “the instruction.” For example, the original MSLQ has the question “During this class I often miss important points because I’m thinking of other things.” In the revised version this question was listed as “During the instruction I often miss important points because I’m thinking of other things.”

The original form of the MSLQ has proven valid and reliable in several studies (Pintrich, Smith, Garcia, & McKeachie, 1993; Garcia & Pintrich, 1994; Garcia, Matula, Harris, Dowdy, Lissi, Davila, & Powdrill, 1995). Reliability alphas for the scales being used in the current study have been shown to be high, demonstrating good internal consistency. The alphas for the non-modified versions of five scales used in the current study are: Metacognitive Self-Regulation, .79; Organization, .64; Elaboration, .75; Self-Efficacy, .93; and Control Beliefs, .68 (Pintrich, Smith, Garcia, & McKeachie, 1993). A mod-

ified version of the Metacognitive Self-Regulation scale used in the current study has been tested in one previous study (McManus, 1996b) and was found to have a coefficient alpha of .75. This is very close to the alpha of the traditional scale. The other modified scales are being used for the first time. Alphas were tested in this study and can be found in the Results chapter.

For the purpose of this study, each subject's individual scores on the five scales were combined into a weighted composite score using factor analysis, where each scale was weighted to reflect how much it contributes to the measure of the construct labeled "self-regulated learning." These weighted composite scores were then trifurcated into groups labeled high, medium, and low. The high group was the top 33rd percentile; the medium group was the middle 33rd percentile; the low group was the bottom 33rd percentile.

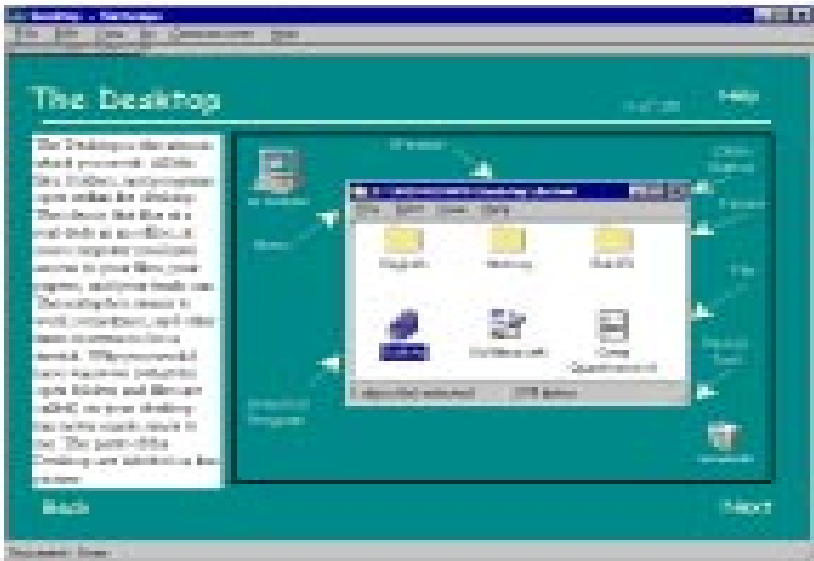
## Treatments

There were two treatment and one classification variables for the study. The classification variable was the level of learner self-regulation as measured by scales from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich and Garcia, 1991), modified for use in a hypermedia environment. Learners were divided into high, medium, and low self-regulating based on their score. Both treatment variables were instructional strategies that can be applied in web-based hypermedia learning environments: the level of nonlinearity of instructional presentation (of which three different levels were used), and the presence or absence of advance organizers. To test these instructional strategies, it was necessary to create three different presentations of the same content with different levels of nonlinearity. Each of these presentations was further separated into those with advance organizers and those without. This is represented in Table 2. The co-variables for the study were prior computer knowledge and computer anxiety. Both were measured by self-report questionnaires. The dependent variable was learner achievement as measured by a two-part posttest. There were six instructional treatment conditions for this study (Table 2). To test these instructional strategies it was necessary to create three different presentations of the same content with different levels of nonlinearity, and for each of these presentations to be further separated into those with advance organizers and those without. Each of the treatments had the same basic information.

**Table 2**  
Instructional Treatments

	Level 2 Nonlinear (Browseable)	Level 3 Nonlinear (Linked)	Level 5 Nonlinear (Interconnected)
With Advance Organizer	Version 1	Version 3	Version 5
Without Advance Organizer	Version 2	Version 4	Version 6

The basic mode of instruction was a simulated MacOS™ or Win95™ graphic user interface (GUI) with textual instructions. The learner was shown how to perform a task (Figure 1), then was asked to follow along with the instructions. Finally she was asked to perform the task without prompts.



**Figure 1.** Screen from Treatment 3.

The instructional environment took advantage of the web’s cross-platform abilities. Students working at Macintosh™ computers were able to access the Windows95™ simulation, just as students working at PCs could access the Macintosh™ simulation. The instructional interface was simple. An example from Treatment 1 is shown in Figure 2. The screen resembled a computer desktop as much as possible. The background was simple and

the buttons unobtrusive. The text box held the instructions. The simulation screen showed animations and provided a space where the learner interactions took place.



**Figure 2.** Screen from Treatment 1

The learner was first presented with a Shockwave™ animation modeling of the action to be learned. Then guided practice using interactive Shockwave™ animations allowed the learner to try the behavior in an authentic environment. If the action to be learned was to create a folder in the MacOS™, the student clicked on the File menu in the simulated GUI and dragged down to New Folder. If this was done correctly, an untitled folder icon appeared on the simulation desktop. The final practice was carried out in the same interactive Shockwave™ animation, but without the written instructions.

The level two versions of the instruction had a simple book based design. A Windows95™ concept, then the equivalent Macintosh™ concept, was shown. There were forward and back buttons and a help button, which lead to the help screen. The level three designs had a back arrow, a menu button, and a help button on each screen. They had a forward button only where there was no other way to advance a particular lesson. The level five designs had multiple menus and internal links on the pages. In each version

with advance organizers, the organizers appeared on a screen before the main content screen. Each organizer screen had a simple text paragraph and a forward button. The organizer screens did not link to other screens, even in the level five version.

### Dependent Variable

The dependent variable for the study was learner achievement. For the course where the *Operating System Basics* instruction is used, the students' achievement is evaluated by the completion of a set of tasks in the operating systems such as creating a file and copying a folder. These tasks are turned in two weeks after the instruction is completed. For the purposes of this research, the two-week period between instruction and evaluation allowed for numerous influences other than the instruction to affect the learners' performance. Therefore, the evaluation of learner achievement for the study was separate from the course evaluation. The declarative knowledge posttest was given immediately following the completion of the instruction and the procedural evaluation was turned in during the next class period.

For this research the dependent variable of learner achievement was measured by a two-part posttest. The two parts of the posttest were a declarative knowledge section and a procedural knowledge section. The declarative knowledge test, 12 multiple-choice questions given at the end of the web-based hypermedia tutorial, measured basic computer knowledge and definitions. Two examples are:

1. What is the difference between a file and a folder?
  - A. a folder is smaller and fits within a file,
  - B. a file is a document or program, a folder is an organizational holder,
  - C. a folder is a picture or movie document, a file is a text or sound document, and
  - D. a file stays on the computer, while folders can fit on a floppy.
2. Like a person, the computer has two main types of memory long term memory and short term memory. What is the long term memory?
  - A. RAM,
  - B. the hard drive,
  - C. My Computer, and
  - D. the Recycle Bin.

The procedural test was a list of 20 tasks to be carried out in the actual operating system, rather than the web-based hypermedia learning environment. As the objectives of the instruction were geared towards performance in an authentic environment, the performance evaluation had to take place in that environment. Examples of the tasks are: "Create a folder and name it FRED" and "Get information on the file to obtain the byte size of the file in the SCHOOL folder." An experienced instructor of the material examined both the Performance Evaluation and the Declarative Knowledge Test for validity. The performance evaluation was almost identical to the evaluation used for the course.

### Concomitant Variables

There were two concomitant variables for this study: computer anxiety and prior computer knowledge. These are learner attributes that were expected to correlate with the subjects' performance on the dependent variable, but were not covered by the research questions of this study. Computer anxiety has been shown to affect learner performance in a computer based learning environment (Hartman, Neuwirth, Kiesler, Sproull, Cochran, Palmquist, & Zubrow, 1991; Marcoulides, 1988), especially for novice computer users (Howard, Murphy, & Thomas, 1987). Therefore it was important to account for the effect this variable may have had on the learner's achievement. Computer anxiety was measured using a modified version of Spielberger's Self-Evaluation Questionnaire. The test is a 20-item, 4 point Likert scale modified by Reed and Palumbo (quoted in Liu, 1992) in order to relate more directly to feelings about computers. Scores range from 20 (very anxious) to 80 (not anxious). The measure has a high reported reliability (Alpha = .93).

Each subject's prior experience with computers in general, the number of operating systems used in the past, and their familiarity with web-based environments may all be reasonably assumed to have some effect on their performance in the *Operating Systems Basics* instructional environment. This prior computer knowledge was measured by a researcher-created three-question survey asking about student computer experience. Each subject's responses were combined to create an individual aggregate prior computer knowledge score. The scores ranged from 3 to 14. The higher the score, the greater the subject's prior knowledge.

## Procedures

The subjects went through the instruction and evaluation during their normal class time. Before the instruction began, each subject was randomly assigned to one of the six instructional treatments. Each student worked alone at a computer in the web-based hypermedia learning environment. Students were shown a given procedure, then allowed to practice it with guidance from the instruction. Finally they practiced the procedure without guidance. Each student was allowed to work with the instruction at their own pace. The class periods were either 90 or 180 minutes long. In the 90-minute classes, subjects worked on the instruction for two class periods. During the first class they went through most of the instruction. In the second class period, two days later, they finished the instruction and took the tests. For the 180-minute classes, the students went through all of the instruction and testing in one period. Most students took about 100 to 110 minutes to complete the instruction. After each student completed the instruction, he or she was tested online for achievement, self-regulation, computer anxiety, and prior knowledge. During the instruction the instructor and her assistants went around the classroom, answering questions the students had about the workings of the program, but not about the content.

While it is possible that testing the levels of self-regulation and computer anxiety after the instruction may have influenced the outcome of those measures somewhat, some of the subjects in this study had never worked in a computer based learning environment before. Therefore they could not give an accurate accounting of their strategy use and level of anxiety in such an environment. By measuring them after the instruction, these novices had some experience on which to report.

## Data Analysis

In order to answer the seven research questions, a 3x3x2 ANCOVA was run. The first variable (A) was self-regulated learning. Factor analysis was used to create the weighted composite scores for the self-regulated learning measure. These scores were then trifurcated into top, middle, and bottom 33rd percentiles. Each group was then labeled: 1 = low, 2 = medium, 3 = high. The second variable (B) was level of nonlinearity: 1 = Level 2, 2 = Level 3, 3 = Level 5. The third variable (C) was advance organizers: 1 = not present, 2 = present (Table 3). The two co-variables were prior knowledge, ranging from 3 to 14, and computer anxiety, ranging from 20 to 80. The dependent variable was the score on the two-part posttest.

While 159 students went through the instruction, only 119 completed all of their evaluations. Because of this discrepancy there are an uneven number of subjects in each treatment group. The full distribution of subjects to the 18 cells is shown in Table 2.

**Table 3**  
Subject Distribution

<b>C1 = Without Advance Organizers</b>			
	A1 = Low SRL	A2 = Medium SRL	A3 = High SRL
B1 = Level 2 Nonlinear	n=3	n=6	n=12
B2 = Level 3 Nonlinear	n=5	n=9	n=4
B3 = Level 5 Nonlinear	n=12	n=4	n=8
<b>C2 = With Advance Organizers</b>			
	A1 = Low SRL	A2 = Medium SRL	A3 = High SRL
B1 = Level 2 Nonlinear	n=6	n=9	n=8
B2 = Level 3 Nonlinear	n=10	n=4	n=12
B3 = Level 5 Nonlinear	n=4	n=7	n=6

Cronbach alphas were run for all measures to test for internal reliability of the measurement instruments.

## RESULTS

Detailed analysis of the data gathered in this study showed the possibility of two real interactions. The first is between nonlinearity of instructional presentation and level of learner self-regulation, which shows that highly self-regulating learners perform worse in mostly linear web-based hypermedia learning environments than in environments where they have more choice and control over their navigation. The second possible interaction is between nonlinearity of instructional presentation and the presence of absence of advance organizers. Advance organizers seem to improve learner achievement in a web-based hypermedia learning environment that is highly nonlinear but lower learner achievement in a mostly linear environment. While these findings are not certain, they are strongly suggested by the results.

Despite the original research design, initial analysis of the data prohibited the use of the analysis of covariance method. The concomitant variables proved to correlate only poorly with the dependent variable. The Pearson product moment correlation for the computer anxiety measure and achievement was almost nonexistent ( $r = 0.01$ ). The correlation for the prior knowledge measure was also very low ( $r = 0.07$ ). Therefore the assumptions necessary for an analysis of covariance were not met. Instead the data were analyzed using a three-way analysis of variance (Table 6). Table 4 shows the achievement means and standard deviation for each cell.

**Table 4**  
Group Achievement Means

<b>No advance organizers</b>						
	Low SR		Med. SR		High SR	
	Mean	SD	Mean	SD	Mean	SD
Low NL	27.67	4.04	29.67	1.50	22.17	6.34
Med. NL	22.80	9.04	25.78	5.45	23.75	7.36
High NL	23.00	6.67	18.50	8.35	22.75	7.90
<b>With advance organizers</b>						
	Mean	SD	Mean	SD	Mean	SD
Low NL	25.67	6.83	23.89	6.64	18.75	8.28
Med. NL	24.40	5.83	26.25	6.24	26.50	3.53
High NL	29.75	1.26	22.57	7.34	23.50	7.82

Before full analysis of the data can take place, the individual MSLQ scale scores must be combined into a single composite score that can then be used to determine each individual subject's level of self-regulation. Factor analysis was used to determine how much each of the scales contributed to the desired composite. The resulting weights are shown in Table 5. Each individual's scale total was multiplied by the weight and then added to create a total self-regulated learning composite score. These scores were then trifurcated into high (top 33rd percentile), medium (middle 34th percentile), and low (bottom 33rd percentile).

**Table 5**  
MSLQ Scale Factor Analysis

<b>Scale</b>	<b>Initial</b>	<b>Extraction</b>
Control Beliefs	1.00	0.62
Elaboration	1.00	0.64
Metacognitive Self-regulation	1.00	0.78
Organization	1.00	0.50
Self Efficacy	1.00	0.68

Cronbach reliability coefficients were computed for each test given the subjects. The alphas are given in Table 6.

**Table 6**  
Reliability Alphas for Modified MSLQ Scales

<b>Measure</b>	<b>Reliability <i>alpha</i></b>
Post test	0.40
Metacognitive Self-regulation Scale	0.67
Elaboration Scale	0.43
Control Beliefs Scale	0.35
Organization Scale	0.39
Self Efficacy Scale	0.48

One observed reason for the low alphas for the revised MSLQ scale was the wording used. In many of the questions the word “program” was used to replace “class.” Many of the learners reported finding this word confusing as they were uncertain whether it referred to the instruction, the web browser, the operating system, or their program of study, that is, their major classes.

The result of the ANOVA (Table 4) showed no significant main effects or interactions, though two interactions, advance organizer by nonlinearity ( $p = 0.052$ ) and nonlinearity by self-regulated learning, showed near significant relationships ( $p = 0.054$ ). The lack of significant findings forced the researcher to fail to reject the null hypothesis, which states there is no difference in knowledge acquisition for any level of nonlinearity or advance organizer for any level of learner self-regulation. Despite this finding, the results do suggest the possibility of meaningful answers to some of the research questions.

**Table 7**  
Results of Three Way Analysis of Variance

<b>ANOVA</b>				
<b>Source</b>	<b>df</b>	<b>SS</b>	<b>F-Test</b>	<b>P Value</b>
Advance Organizers (AO)	1	7.91	.18	.674
Nonlinearity (NL)	2	45.54	.51	.600
Self-regulated Learn (SRL)	2	106.15	1.19	.307
AO * NL	2	270.75	3.05	.052
AO * SRL	2	29.51	.33	.718
NL * SRL	4	429.19	2.42	.054
AO * NL * SRL	4	48.89	.27	.893
Error	101	4484.61		
Total	119	5422.55		

### Answers to the Research Questions

The results for research question one, “Can learner self-regulation affect knowledge acquisition in a web-based hypermedia learning environment?”, do not support an affirmative answer. Table 8 shows the means and standard deviations for the three levels of learner self-regulation. Analysis of variance shows no significant main effect for this variable ( $p = 0.307$ ; Table 7).

**Table 8**  
Self-regulated Learning Group Means

	<b>Mean</b>	<b>SD</b>
Low SRL	24.75	6.37
Med. SRL	24.67	6.51
High SRL	22.18	7.15

The results for research question two, “Which level of nonlinearity is most effective for promoting knowledge acquisition in a web-based hypermedia learning environment?”, do not support an affirmative answer. Table 9 shows the means and standard deviations for the three levels of nonlinear presentation. Analysis of variance shows no significant main effect for this variable ( $p = 0.600$ ; Table 7).

**Table 9**  
Nonlinear Group Means

	<b>Mean</b>	<b>SD</b>
Low NL	23.77	6.92
Med. NL	24.79	6.06
High NL	23.17	7.13

The results for research question three, “Can advance organizers improve knowledge acquisition in a web-based hypermedia learning environment?”, do not support an affirmative answer. Table 10 shows the means and standard deviations for the groups with and without advance organizers. Analysis of variance shows no significant main effect for this variable ( $p = 0.674$ ; Table 7).

**Table 10**  
Advance Organizer Group Means

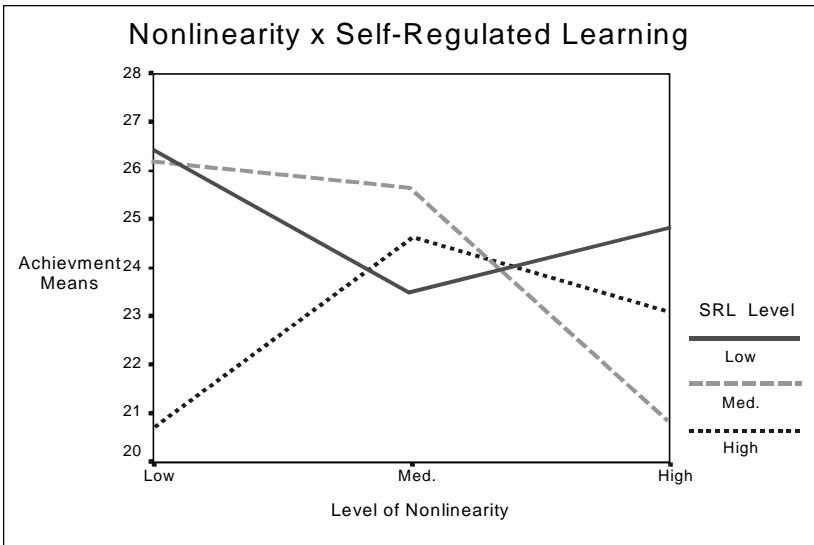
	<b>Mean</b>	<b>SD</b>
No AO	23.81	6.72
With AO	23.91	6.82

The results for research question four, “Can nonlinearity affect knowledge acquisition differently for each level of learner self-regulation in a web-based hypermedia learning environment?”, were inconclusive, but strongly suggestive of an interaction. Table 11 shows the means and standard deviations for the SRL(3) x NL(3) interaction. Analysis of variance shows a near significant ( $p = 0.054$ ; Table 7) interaction for these two variables. Figure 3 displays the interaction.

The results suggest that the level of nonlinearity may affect learning for some learners. In the low nonlinear environment, low and medium self-regulated learners scored relatively well. These were the groups with the highest means. High self-regulated learners scored least well in this environment. The group means in the medium nonlinear presentation seemed to cluster more closely than in the other two environments. In the high nonlinear environment, group means for high and medium self-regulated learners were lower than the mean for the low self-regulated learners, much lower in the case of the medium self-regulated learners. The group mean for low self-regulated learners was somewhat higher than in the medium nonlinear environment.

**Table 11**  
Nonlinearity x Self-Regulated Learning Group Means

	Low SR		Med. SR		High SR	
	Mean	SD	Mean	SD	Mean	SD
Low NL	26.33	5.85	26.20	5.88	20.80	7.17
Med. NL	23.87	6.77	25.92	5.44	24.67	6.09
High NL	24.68	6.49	21.09	7.58	23.07	7.57

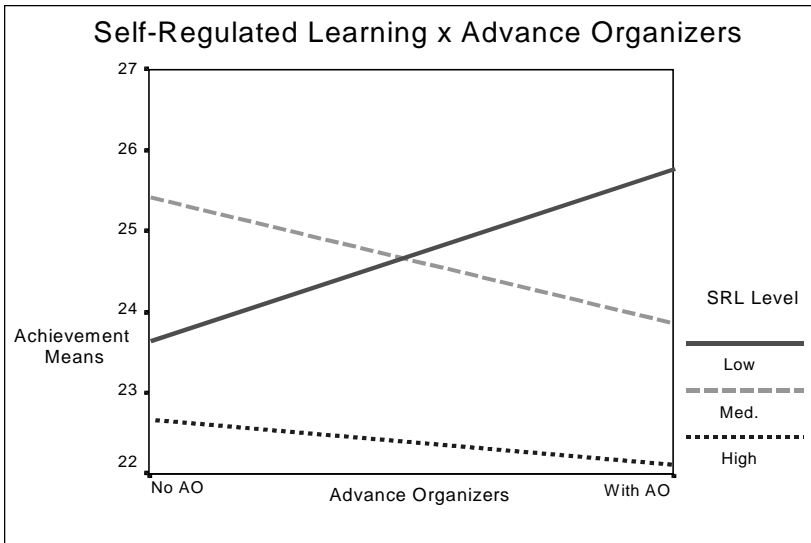


**Figure 3.** Nonlinearity x Self-Regulated Learning

The results for research question five, “Can advance organizers improve knowledge acquisition for each level of learner self-regulation in a web-based hypermedia learning environment?”, do not support an affirmative answer. Table 12 shows the means and standard deviations for the SRL(3) x AO(2) interaction. Figure 4 plots the interaction. Analysis of variance shows no significant interaction for these two variables ( $p = 0.718$ ; Table 7).

**Table 12**  
Advance Organizer x Self-Regulated Learning Group Means

	Low SR		Med. SR		High SR	
	Mean	SD	Mean	SD	Mean	SD
No AO	23.65	6.91	25.47	6.49	22.63	6.76
With AO	25.85	5.74	23.90	6.60	21.50	7.88



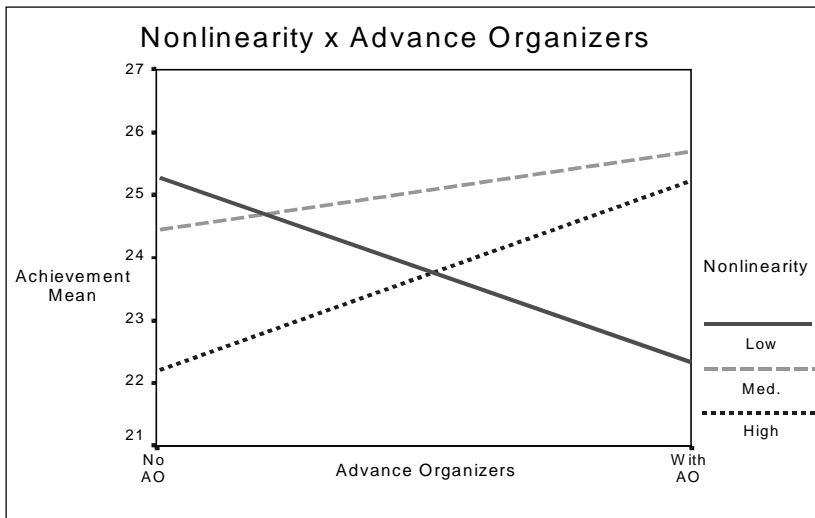
**Figure 4.** Self-regulated Learning x Advance Organizer

The results for research question six, “Is there a significant interaction between level of nonlinearity and the presence of an advance organizer in a web-based hypermedia learning environment?”, were inconclusive, but strongly suggestive of an interaction. Table 13 shows the means and standard deviations for the AO(2) x NL(3) interaction. Analysis of variance shows a near significant ( $p = 0.052$ ; Table 7) interaction for these two variables. Figure 5 displays the interaction. The group mean score in the low nonlinear environment with no advance organizers was much higher than the group mean score in the low nonlinear environment with advance organizers. The group mean scores in the medium and high nonlinear environments, with no advance organizers, were lower than the group mean scores

in the medium and high nonlinear environments with advance organizers. This seems to suggest learners in the high nonlinear treatment performed better when there was an advance organizer present, while learners in a low nonlinear environment performed less well when an advance organizer was present.

**Table 13**  
Nonlinearity x Advance Organizer Group Means

	Low NL		Med. NL		High NL	
	Mean	SD	Mean	SD	Mean	SD
No AO	25.10	6.06	24.50	6.68	22.17	7.23
With AO	22.57	7.55	25.13	5.48	24.59	6.96



**Figure 5.** Nonlinearity x Advance Organizer.

The results for research question seven, “Is there a significant interaction between level of nonlinearity and the presence of an advance organizer for each level of learner self-regulation in a web-based hypermedia learning environment” do not support an affirmative answer. Table 4 shows the means and standard deviations for the SRL(3) x NL(3) x AO(2) interaction. Analysis of variance shows no significant interaction for these three variables ( $p = 0.893$ ; Table 7).

## DISCUSSION

### Effects and Interactions

This study showed no significant main effect for self-regulated learning. That is, those who tested as high self-regulating did not score significantly better than those who tested as medium or low self-regulating. This is somewhat surprising, as it contradicts the findings of other studies (Pintrich & De Groot, 1990; Zimmerman & Martinez-Pons, 1986); which have shown the general efficacy of self-regulated learning in improving achievement. Even a prior study (McManus, 1996b) showed that high self-regulated learners performed better in a web-based hypermedia learning environment. There are a number of possible explanations for this. The learners' unfamiliarity with the learning environment in this study may have had something to do with the lack of score differences. In the earlier McManus study, the majority of the subjects were experienced computer or web users. In a survey of subjects taken several weeks after the current study 25 out of 35 respondents said they had never used a computer based tutorial before. It is possible that the students who tested as high self-regulating may have not been familiar enough with the environment to know how to apply self-regulation strategies to their best effect. It should also be noted that the subjects were assigned to high, medium, and low self-regulation groups based on their composite score. The MSLQ was created to be given as a number of independent scales, each measuring a discreet construct within the overall concept of self-regulated learning. Therefore the combining of five of these scales into a weighted composite may not have been an effective method for classifying the learners. Finally, the near significant self-regulated learning by nonlinearity interaction may also account for the lack of main effects. That is, high self-regulating learners were not able to use all of their strategies in the mostly linear instructional treatments, which may have caused them to score lower than they might otherwise have.

The lack of significant main effect for nonlinearity of instructional presentation in this study is not entirely unexpected. Numerous studies have compared the effect of linear versus nonlinear texts on learner achievement (Alexander, Kulikowich, & Jetton, 1994). The bulk of the literature shows little conclusive result (Arnone, Grabowski, & Rynd, 1994; Shin, Schallert, & Savenye, 1994). Several have shown improved knowledge acquisition in nonlinear environments (Egan, Remde, Landauer, & Gomez, 1989; Gray, Barber, & Shasha, 1991; Yang, 1992), while others have shown no significant improvement (Dillon, 1991; Frau, Midoro, & Pedemonte, 1991; Lanza & Roselli,

1991). It is possible that looking at nonlinearity in isolation from other instructional strategies or from learner characteristics caused the inconsistent results. In this study the effects of nonlinearity were better examined in relation to the other variables. Near significant interactions were found between nonlinearity and both of the other variables.

The lack of significant main effect of advance organizers in this study likewise was not unexpected. Like the nonlinearity studies, research evidence on the effect of advance organizers on learner achievement has been mixed. Some studies showed that the presence of advance organizers could improve knowledge acquisition (Kenny, 1995; Mayer, 1975, 1976). Others seem to suggest that advance organizers have no real effect (McEnany, 1990; Saidi, 1994). This lack of conclusive results is one reason to explore possible interactions between advance organizers and other strategies and attributes. This study found a near significant interaction between advance organizers and nonlinearity.

The near significant interaction ( $p = 0.054$ ) between nonlinearity and self-regulated learning may reflect the effort nonlinear learning environments demand from the learner. Jonassen (1988) points out that nonlinear designs require learners to take a more active role in organizing the information in the instruction. Not every learner works well when given control over the organization of their instruction. Some benefit from more inherent structure. The strategic requirements for a learner in a nonlinear environment are much greater than in more traditional environments. The more nonlinear the design, the more responsibility is placed on the learner. Therefore it should be expected that not all learners will be able to perform this task equally well (Rouet, 1992).

The results from this study show that highly self-regulating learners perform poorly in the environment with the lowest level of nonlinearity, while medium self-regulating learners fared poorly in the highest nonlinear treatment. The relatively high scores of low and medium self-regulated learners in the low nonlinear environment could indicate that the preorganized presentation was effective in organizing the instruction for these learners, while the lack of control restricted the use of personalized self-regulation strategies for the high self-regulated learners. The medium nonlinear environment seemed to be the most effective environment for high self-regulating learners. It offered more choice than the low nonlinear environment, and allowed learners to organize the content in a personally relevant manner. The low scores of the high and, particularly, medium self-regulating learners in the high nonlinear environment may reflect their inexperience in the medium more than lack of strategy use, though it also may be that this environment does not lend itself to self-regulation strategy use and is unsuitable for

these learners. For medium self-regulated learners in particular, it is possible that the most nonlinear presentation offered too many choices. These learners may not have had the strategies necessary to monitor their progress and may have gotten lost. The relatively high scores of the low self-regulating learners in the high nonlinear environment may show that these learners' non-strategic traversal of the environment fit well with the design of the instruction. Simply accessing every page in the environment would have exposed these learners to all the information needed to pass the test.

Learner performance and preference seem to be somewhat at odds when it comes to nonlinearity. The majority of the subjects who responded to the learner preference survey given after the study seemed to prefer the more linear presentations. In the survey subjects were asked, "When you were going through the instruction did you want more choices to follow, fewer choices, or were there the right number of choices?". Eighty percent of the respondents who went through the linear presentations seemed to think there were the right number of choices. Sixty six percent of the respondents in the medium nonlinear presentations seemed to think there were the right number of choices. Only 29% of the respondents in the highly nonlinear presentations thought there were the right number of choices. While survey responses were not correlated with self-regulated learning scores, for reasons of confidentiality, it is still possible to deduce some conclusions. Of the 46 subjects who went through the mostly linear presentations, 20 scored as highly self-regulated learners. That means 43% of the people did poorly in that treatment. Compare that to the 80% who thought the number of choices was appropriate. This suggests that learners' preferences do not always coincide with the best environment for them. This may be because of unfamiliarity with the medium. For novice computer users, the comfort of a linear presentation may be appealing, regardless of its instructional merit.

The near significant ( $p = 0.052$ ) nonlinearity by advance organizer interaction suggests that advance organizers have a negative effect in a low nonlinear instructional treatment and a positive effect in a high nonlinear treatment. This result appears to be in line with earlier findings that advance organizers are more effective in less organized text (Mayer, 1978). Few empirical studies have examined the interaction of nonlinearity and advance organizers in a hypermedia environment. Mayer (1978) looked at the interaction of two text presentations, one randomly ordered and the other logically ordered, and advance organizers. The group that read the randomly ordered text benefited more from the presence of the advance organizers than did the group with the logically organized text. He concluded that the advance organizers provided the schema needed for subsumption, which was lacking in

the randomly organized text, while the logically organized text provided its own schema.

Mayer's conclusion appears to be borne out by the results in the current study. The relatively high mean for the low nonlinear environment can be taken as a baseline. This is the mean that is influenced by neither advanced organizers nor nonlinearity. As either, or both, of these variables are introduced, the group means change. The introduction of greater nonlinearity, without the organizational aid of advance organizers induces, lower group means; the more nonlinear the lower the mean. When advance organizers are included in the instruction, means for both medium and nonlinear environments are higher. Only in the case of the low nonlinear environment with advance organizers, is the group mean lower. This may mean that the structure offered by the advance organizers may actually interfere with the structure inherent in the linear presentation. Advance organizers seem to give learners early warning that may enable them to better organize the new information presented in the nonlinear environments. Whether they made a positive difference or not, the majority of learners seemed to prefer to have advance organizers. In the survey 66% of the subjects who had advance organizers thought they were helpful.

### **Context of the Findings**

Several factors about the instruction used in this study should be examined to help place the results in context. The instruction was a web-based tutorial on introductory level procedural knowledge, the basics of the Macintosh™ and Windows95™ operating systems. It was given as a regular part of an undergraduate computer integration class. These circumstances produced certain consequences that may have affected the outcome of the study, possibly contributing to the lack of significant differences.

The use of introductory instruction may have reduced the effectiveness of the advance organizers, as the learners had fewer relevant preexisting schemata to activate. Advance organizers work in two ways. They create a bridge between prior knowledge and new information and they help learners organize the new information in an effective way. The advance organizers in this study seemed to have been effective in some cases by offering a structure to help the learner to organize the new information. In the current study, the subjects' lack of prior knowledge relating to the control of computers through a graphic user interface meant that the advance organizers had to try to tie the new information on copying files and opening programs to

schema relating to offices and objects. This may have made the advance organizers less effective than if the learners had schemata more closely related to the new information.

The fact that much of the instruction was procedural limited the nonlinearity of the design. Given the nature of the information to be learned, numerous short operating system procedures that are mostly unconnected to each other, there was a limit to how nonlinear the instruction could be. Saving a file to a disk, for instance, has little to do with creating a new folder. Therefore, the instruction was made up of numerous discrete chunks that could be accessed, depending on the treatment, either in a preselected sequence, through a single menu, or through numerous menus and internal links. But once the given chunk, the OS command, was chosen, the instruction on the procedure was necessarily linear. When demonstrating how to rename a file it is necessary to follow the series of commands from beginning to end. This linearity within relatively large chunks may have affected the influence of the different levels of nonlinearity on the dependent variable.

The outcome of the study may have been affected by the fact that the instruction given was a regular part of a university course. All of the subjects were required to master the content of the instruction or risk failing a course necessary for their degree. This meant that the instructors, including the researcher, were required to answer student questions and offer help during both the learning and evaluation phases of the study. Due to the requirements of the course, students were allowed to complete the Performance Evaluation part of the posttest on their own, outside of instructor supervision. It is possible that some of the evaluations turned in did not accurately reflect the knowledge acquisition of the individual subject, as some subjects were observed collaborating with each other or seeking help from instructors and lab assistants on the performance evaluation. This collaboration is allowed in the class, so little could be done to prevent it for the sake of the study. These problems are characteristic of studies conducted in real classroom situations.

While it cannot be proven that any of these circumstances directly affected the results of this study, any one could have had a dramatic effect. The combined influence of these factors has to be considered when determining the validity and applicability of the findings and should be considered when designing future research in the field.

## CONCLUSIONS

The practical significance of this study is limited by the lack of statistically significant results. While no concrete conclusions can be drawn, the results do support further investigation into the possibility of differential effects of nonlinearity and advance organizers for learners with different levels of self-regulation. If future studies confirm the findings, then certain practical recommendations can be made. Web-based hypermedia learning environments designed for students with high levels of self-regulation should offer the learners more choice than can be found in a mostly linear environment. Students who possess the ability to actively monitor and control their learning will benefit from the ability to organize and structure their instruction offered in more nonlinear environments. Medium self-regulated learners function less well in very nonlinear instructional environments than they do in more structured environments. Therefore, if the learner's level of self-regulation is known, the learning environment can be tailored to meet his/her needs. The use of instructional strategies can also be adjusted depending on the learning environment. In a moderate to highly nonlinear web-based hypermedia environment, the designer might consider adding advance organizers to help the learners activate prior knowledge and organize the information presented. In a more linear environment, advance organizers seem to have no beneficial effects, possibly even negative effects, and should therefore not be used.

The results of this study support the continued exploration of the field of individualized instruction. The near significant interactions, while inconclusive on their own, can be used as a basis for future studies into the interaction of self-regulated learning, nonlinearity, and advance organizers. Given the possible effect of the context of this study, future research should examine the same basic variables, but in a different setting. The instruction should be intermediate or advanced level instruction in an ill-structured learning domain. It should not be a required part of a course. While adding more controls to the study will limit its generalizability, doing so will increase the chance of finding basic results that can then be verified further in more authentic situations. Using the MSLQ scales separately to examine the construct and the interaction of various self-regulation strategies with the instructional strategies might also provide for better basic results. Once the various self-regulation strategies that do affect learning in a given environment have been found, they can be used to define larger self-regulation constructs.

## Recommendations for Further Study

This study looked at the effects of self-regulated learning, nonlinearity, and advance organizers on knowledge acquisition. Future studies might examine the effects of these same variables on knowledge retention or transfer. Future researchers might explore whether more nonlinear environments might help highly self-regulated learners build flexible schema that can then be transferred more easily. Or they could explore whether or not advance organizers help low self-regulated learners organize their information in such a way that it can be accessed more easily at a later date.

Another related field that would benefit from more study is the evaluation of self-regulated learning in a hypermedia environment. Finding a way of assessing the actual use of self-regulated learning strategies within an environment through pattern analysis would be more effective for automatically individualizing instruction than self-report measures such as the MSLQ. Learners who actually control their own learning in a given web-based hypermedia environment could be given more choices and more control, whereas less active learners could be given more structure. This individualization will be difficult without accurate contextualized assessment of strategy use and learner attributes.

Finally, other learner profile/instructional strategy interactions could be explored. Computer anxiety and prior knowledge were tested in this study to be used as covariables. When they did not correlate with the achievement variable, they were dropped from the design. Other studies might look at them as parts of a more complex learner profile. Other instructional and presentation strategies such as level and type of feedback, the use of interactivity, or the presence of various media could also be explored in relation to self-regulated learning or other learner profiles. While complex, multivariable interaction studies are hard to perform, they are necessary to develop an accurate picture of the complexities of individual learning environments, and the learners in them, to shape the environment to meet the needs of the learner.

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