The Effects of Locus of Control and Navigational Control on the Performance of Students in a Hypermedia Environment

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(ABSTRACT)

The purpose of this study was to examine the effect of various navigational control options within a hypermedia learning environment on the performance of students who differed in their locus of control orientations. Ninety-three college students were classified as internal or external in their locus of control orientation based on their scores on the Adult Nowicki-Strickland Locus of Control Scale (ANSIE). They were then randomly assigned to one of three treatment groups that differed in the way participants navigated through a hypermedia instructional program dealing with the human heart. In the Linear group, participants navigated through the program in a standard linear fashion. In the Branching group, participants navigated through the program with the help of a hierarchical menu structure. In the Networked group, participants had the additional option of using embedded (associative) hyperlinks. At the conclusion of the program, participants completed a posttest that assessed two types of learning. A 2 X 3 Analysis of Variance was conducted to explore the main effects for locus of control (internal and external) and navigational control (linear, branching, and networked) and any interaction effect between the two factors. The results showed no significant differences in achievement based on participants' locus of control orientation or treatment group. There was also no significant interaction observed. The results provided no support for the hypothesis that different navigation options would improve the performance of learners differing in their locus of control orientation.

Sapere Aude!

DEDICATION

This work is dedicated to all the great teachers I have had throughout my life. I would not be here without you. The teachers I remember fondly are the ones who always conveyed their passion for learning, even in the face of apparent indifference. Remember that even though the seeds you sow may not immediately spring forth, in time they may blossom into a magnificent garden.

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TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER I: INTRODUCTION AND REVIEW OF LITERATURE

Introduction

There is a great deal of interest being expressed concerning the use of hypermedia in learning. With the multitude of tools available today, instructional materials can be easily developed that support student-centered learning, providing students with powerful sources of information. However, as with traditional learning materials, designers should make sure that they are developing the most effective learning environments for students. What factors should be considered when attempting to create effective hypermedia environments? To answer this question one must look at two broad categories of factors: *external* and *internal.*

External factors are related to the environment where learning takes place, and include things such as instructional strategies, delivery system, teacher competency, and the physical environment itself. External factors are brought to the learning experience by designers and educators. These factors are external to the student and are more or less under the control of instructional designers and teachers. Therefore, they can be experimentally manipulated and adjusted to fit different learning situations.

One specific external factor is learner control. The issue of learner control has increasing relevance as more students interact with hypermedia-based instructional materials. The amount of learner control is generally determined by instructional designers and developers, so it is vitally important to understand how different students make use of learner control options.

Internal factors are related to individual learner characteristics, such as intelligence, gender, prior achievement, prior knowledge, aptitudes, attitudes, learning styles, cognitive styles, motivation, socioeconomic status, and many others. Internal factors are brought to the learning experience by the learners themselves. These factors are internal to the student and cannot be easily manipulated. However, they must be identified and recognized for their influence on learning. It is thought that knowledge of the internal factors can help designers adjust the external factors in ways that will accommodate unique differences between learners, thereby improving the effectiveness of instructional materials.

One specific internal factor is locus of control. Due to of the nature of this construct, locus of control warrants close consideration when determining which internal factors have the potential to influence the effectiveness of hypermedia-based instructional materials. This is particularly true considering hypermedia is ripe for creating open-ended, learner-controlled instructional environments.

This study looked at learner control and locus of control and their possible interaction within a hypermedia learning environment. As the popularity of hypermedia increases, it is important to be able to provide instructional designers and educators with guidelines for the development of hypermedia instructional materials. It was expected that the results of this study would add to the research that explains which instructional strategies are most appropriate for different types of learners. It might also help explain which types of learners will function best in hypermedia environments and which may need additional assistance to be successful.

Review of Literature

Hypermedia

With the increasing presence of the Internet in educational environments, the interest in hypermedia-based learning has grown enormously. Highlights of hypermedia include flexibility, nonlinear access to information, increased interactivity, multiple media, and the ability to provide learners with more control of the learning process. In particular, Web-based learning environments provide the ultimate in hypermedia, with students able to link to sites throughout the world. Although much has been written about hypermedia-based learning, too little of this writing has been based on research. Most of the early articles about hypermedia made predictions of hypermedia's potential, described the development of hypermedia-based systems, or gave reasons why hypermedia should be effective for learning (Ayersman, 1996). Hypermedia has often been touted as a way to supplement or even supplant traditional forms of instruction. With so many schools and organizations now creating and using hypermedia instructional materials, valid research is needed to help instructional designers maximize the quality and effectiveness of learners' experiences.

Overview of Hypermedia

Hypermedia originally began as *hypertext*, a term coined by Ted Nelson in the 1960s. Hypertext is a non-linear system consisting of *nodes* (chunks of information) and *links* (connections between the chunks of information). In a hypertext system, the users can jump between different nodes as they wish using the links that a designer provides. “Connections between information nodes create and define understanding more so than the information itself, suggesting that hypertext linkages supply (or imply) meaning beyond the literal contents of the nodes themselves” (Gall & Hannafin, 1994, p. 223). In addition, because they are designed to be nonlinear, users are encouraged to explore on their own and construct webs of information that have personal meaning to them (Tolhurst, 1995).

Although the terms *hypertext* and *hypermedia* are often used interchangeably, it helps to differentiate between the two. Some definitions refer to hypertext nodes as including only textual information and hypermedia as being an extension of this with nodes that can incorporate information represented by various forms of media. When the term hypertext first came into use, computer systems that used the node and link idea were mainly set up to display textual information. However, as technology progressed, the graphics and multimedia capabilities of computer systems improved greatly, and the term hypermedia became more common. Tolhurst (1995) believes that the definition of hypertext can now be expanded to include static media such as graphs, diagrams, tables, and pictures but not active media such as animation, video, or audio. With the inclusion of these active elements, you move into the realm of hypermedia.

Thus, a hypermedia system can be defined as a non-sequential, non-linear method for organizing, displaying, and linking information in the form of text, graphics, animation, sound, and video in a way that allows users to follow a variable path of associations based on semantic links. Hypermedia learning environments provide access to a wide range of information represented by text, graphics, audio, and video all integrated together as one learning resource. The nodes of information can be linked together in almost unlimited ways to create a sophisticated knowledge network.

Another term often used interchangeably with hypertext and hypermedia is *multimedia.* Multimedia can be considered a more general term for describing the use of two or more media to communicate information. The media used can include text, graphics, sound, and video. However, multimedia does not necessarily indicate the use of a computer technology to present these media, nor does it indicate an instructional component. Indeed, many computer (and non-computer) applications that are termed “multimedia” are not educational at all. Therefore, multimedia can be thought of as a broader term that encompasses hypermedia and for the most part, hypertext. Another way to look at the distinction is to think of hypermedia as the intersection of hypertext and multimedia.

The most common example of a hypermedia system is the World Wide Web. This hypermedia-based system allows users to access information from nodes available around the world. Indeed, the HTTP seen in most Web addresses stands for “*Hypertext* Transfer Protocol.” The protocol was originally designed as a way to transfer text files across large computer networks. The language that was used to create these text files was referred to as the “Hypertext Markup Language,” or HTML. It was after interest began to grow and computer capabilities advanced that programmers figured out that they could expand their use of HTTP and HTML to include a wide variety of multimedia elements. These days HTTP might better be called HMTP, for “*Hypermedia* Transfer Protocol.”

Cognitive Aspects of Hypermedia

Cognitive psychologists view learning as a reorganization of knowledge structures. These structures are represented by semantic networks. Learning then consists of building new structures by linking new information with existing information. The more links that can be created between existing and new information, the better the new information will be understood and remembered (Jonassen, 1991). Because learners have different existing knowledge structures and different mental strategies for assimilating new information, it would seem logical that learners would be best served by presenting new information in a way that can be adapted to their individual learning styles. Hypermedia is highly adaptable to individual cognitive needs, as it is flexible enough to present information in many different ways.

According to cognitive psychologists, learning is an active, individual process that involves the restructuring of knowledge structures in the brain. How this knowledge is structured varies according to different theories. One of the most common explanations is provided by *schema theory*. In schema theory, learning is the accumulation and organization of different knowledge structures. These knowledge structures represent the various concepts in our semantic memory. Each knowledge structure exists as an object, idea, or event as well as a set of attributes that link it to other knowledge structures. These arrangements of knowledge in the brain are referred to as schemas. Schemas are created through experiences with people, objects, and events in the world. Everybody has different experiences, so everyone develops a somewhat different view of the world. For example, an individual's schema for a cat might include attributes such as *small, furry, four-legged, purrs, meows, litter box,* etc.

Schemas have a variety of associated attributes that are based on our individual experiences. When we encounter something repeatedly, such as a cat, we begin to generalize across our experiences to develop an abstracted, generic set of expectations about what to expect when we see a cat. Another individual's schema for a cat might be somewhat or completely different depending on that person's previous experiences with cats. In addition, individual attributes might be associated with many different schemas; the attribute *four-legged* could mean a cat, dog, or horse. However, a complete group of attributes taken together forms our perception of an individual concept. These attributes and schemas interconnect to form a vast network of knowledge known as a semantic network (Jonassen, 1988). The schemas in this network are connected by way of these various associations. “These interconnections enable learners to combine ideas, infer, extrapolate, or otherwise reason from them” (Jonassen, 1988, p. 13).

Learning consists of integrating new information within these existing knowledge structures. In essence, there are three different reactions that a learner can have to new information: accretion, tuning, and restructuring. In accretion, learners take the new input and assimilate it into their existing schema without making any changes to the overall schema. Tuning occurs when an individual's existing schema is inadequate for the new knowledge. In this case, the existing schema is modified accordingly. Finally, restructuring is the process of creating a new schema that addresses the inconsistencies between the old schema and the newly acquired information.

For example, for the cat schema, if a person suddenly found out that cats have sharp claws, then the new attribute of *sharp claws* would be assimilated into the existing schema. However, if that person suddenly discovered that lions, tigers, and cougars are also cats, then the existing schema would need to be modified to accommodate this new information. In view of this new information, the previous attributes of *small* and *litter box* may not be entirely appropriate for the broad cat schema. Finally, if that same person saw a porcupine for the first time, the existing cat schema would not adequately accommodate the new information, and a new schema would have to be constructed to accommodate the porcupine. The new schema would undoubtedly share some of the same attributes (e.g. *small* and *four-legged*), but would be a different concept.

It is theorized that hypermedia is particularly effective at facilitating learning because it reflects a model of learning based on schemas. Many researchers believe that people will learn better when the information to be learned is structured similarly to the way knowledge is stored in the brain (Jonassen, 1988). Hypermedia systems resemble this schema-based structure of knowledge in that the various nodes of information are connected by links to form a large network of information, thereby mirroring the structure of human memory. Marchionini (1988) states, “Proponents of hypermedia systems claim that these systems model human associative memory and thus can serve as powerful cognitive amplifiers” (p. 8). In this theory, hypermedia nodes are devices to represent schema in the user's cognitive structure, and hypermedia links are said to represent the semantic relationships among the schema (Park, 1991). The more links that can be created between existing and new information, the better the new information will be understood and remembered (Jonassen, 1991).

The question is whether an arrangement of the learning environment that is similar to the way information is processed in the brain can facilitate learning. Just because the brain organizes information in this manner does not mean that it wants to receive information in this manner. Jonassen (1988) believes that hypermedia instructional materials can indeed be used to accommodate individuals' differing knowledge structures:

> In hypertext, readers are not constrained by the subject matter structure or by the author's organization of the text. Since an individual's knowledge structure is unique, based on his or her own experiences and abilities, the ways that individuals prefer to access, interact with, and interrelate information is also distinct. In order to accommodate the text to the learner, rather than the learner to the text or its implicit structure, the text structure should be under the control of the learner. In order to get the most from accessing information, learners should be encouraged to explore information and even alter it in ways that make sense to the learner. Hypertext permits these activities. (p. 14)

Much of the current or potential success of hypermedia can also be attributed to Paivio's dual coding theory (1991). According to Paivio's theory, humans process verbal and nonverbal information using different representational systems. The two subsystems are structurally and functionally distinct. Structurally, they differ in how informational units are represented and organized into higher order structures. Functionally, they are independent in that either system can be active alone or both can be active at the same time. In addition, actions taking place in one system can initiate activity in the other. Information can be processed using one or both of these systems; research seems to indicate that people learn better when information is processed through more than one channel as opposed to just one. Dual processing produces an additive effect because the learner creates more cognitive paths to the information, which facilitates later recall. The consensus is that since hypermedia facilitates dual coding, learning with hypermedia can be more effective. “These multimodal approaches to education are thought to be particularly effective for accommodating students with diverse styles and preferences for learning” (Ayersman, 1996, p. 507).

Many researchers believe that hypermedia is particularly well suited for providing instruction in ill-structured learning domains. According to *cognitive flexibility theory*, theories of learning that dominate introductory learning domains are inadequate when learning goes beyond the introductory stage and moves into learning domains where tasks become more complex, dynamic, and ill-structured (Spiro & Jehng, 1990). According to cognitive flexibility theory, hypermedia instruction that is designed for advanced domains should (a) avoid oversimplification and emphasize the interconnectedness of ideas, (b) provide multiple representations of learning content instead of relying on single schemas to describe objects or events, (c) use case-based instruction to illustrate the multiple perspectives of the content to be learned, (d) use practical, real-world contexts to allow the transfer of basic concepts and theories to be applied in dynamic situations, and (e) allow learners to develop their own knowledge representations (Spiro & Jehng, 1990). While cognitive flexibility theory is similar to other cognitive theories, there are critical differences:

> Conceptual complexities and across-case inconsistencies in ill-structured knowledge domains often render the employment of prepackaged (‘precompiled’) schemas inadequate and inappropriate…. Instead of retrieving from memory a previously packaged "prescription" for how to think and act, one must bring together, from various

> knowledge sources, an appropriate ensemble of information suited to the particular understanding or problem-solving needs of the situation at hand. (Spiro, Feltovich, Jacobson, & Coulson, 1991, p. 28)

Because of the emphasis on having learners construct knowledge, this theory is constructivist in nature and more suited to hypermedia environments as opposed to traditional, linear, computer-based instructional environments. Spiro and Jehng believe that computers, and even more importantly, hypermedia systems, are ideally suited to fostering cognitive flexibility because they can better covey ill-structured aspects of knowledge. Both schema theory and cognitive flexibility theory place a great deal of emphasis for learning on prior experience and describe learning as a uniquely individual process (Ayersman, 1993).

Research in Hypermedia Environments

It is predicted that hypermedia will have numerous educational benefits. Marchionini (1988) describes three characteristics of hypermedia that have great potential for learning. One characteristic is the huge amount of information that can be stored and accessed using dynamic links. Another characteristic is the fact that hypermedia can allow high levels of learner control. “Learners may choose to follow well-marked trails of explicit links or blaze new trails according to their individual abilities and objectives” (p. 9). The final characteristic is the potential of hypermedia to alter the roles of teachers and learners along with the interactions between them.

So far, the results of hypermedia studies have been mixed. Chen and Rada (1996) reviewed 23 studies involving hypertext and concluded that the results did not indicate that hypermedia promoted greater achievement. Dillon and Gabbard (1998) reviewed 30 studies involving hypermedia. Many of them involved comparisons between instruction delivered via hypermedia and instruction delivered via some other form of media (e.g., paper or videodisk).

Similar types of studies were identified by Ayersman in his overview of hypermedia (1996). These qualify as media comparison studies and are of little help because they use “hypermedia” as a broad variable instead of looking at the attributes that are unique to hypermedia. As can be expected, most of these studies found no significant difference between hypermedia and paper-based instructional materials. However, Ayersman did cite some studies in which low ability learners seemed to perform better using hypermedia materials as opposed to conventional materials. This may signify an innate ability of hypermedia to excite low ability users enough so that they attend more to the instruction.

As suggested by cognitive flexibility theory, hypermedia might be better suited to presenting complex material as opposed to presenting factual knowledge. Jacobson and Spiro (1995) explored the use of hypermedia to acquire complex and ill-structured knowledge. They used three treatment groups. One group used a computer-based program, a second one used a hypermedia program with minimal features, and the third group used a fully featured hypermedia program. The results showed that students in the computer-based and minimal hypermedia groups performed significantly better when it came to recalling factual material, but students in the fully featured hypermedia group performed better when it came to complex problem-solving tasks.

Another purported advantage of hypermedia-based instruction is its potential to systematically provide for different learner needs and abilities. It is assumed that not all methods of arranging instructional events are equally well suited for all sets of learner characteristics. Once again, there is inconclusive research to support this theory. However, a study by Melara (1996) found that hypertext instruction that was supported by network structures accommodated different learning styles better than hierarchical structures and that both equally accommodated those who preferred observation and those who preferred experimentation. Hypermedia has also been expected to improve learners' attitudes and motivation to learn. Becker and Dwyer reported that students using hypertext experienced an increased sense of control and an increased level of intrinsic motivation to learn. Ayersman (1996) concludes that "generally speaking, positive attitudes are reported following hypermedia-based learning situations" (p. 505).

While hypermedia seems attractive for educational purposes, it also has the potential to negatively affect learning. Whalley (1990) refers to hypertext as a *fragmented* text form and thus potentially flawed as a means of instruction. Because of this fragmentation effect, it can become difficult for the learner to determine an appropriate structure to the information unless certain linear constraints are imposed on the environment. However, Whalley goes on to add that the *malleability* of hypertext provides for potential benefits to learning. The information contained in a hypermedia system can theoretically be accessed in many different ways and from multiple perspectives. The ability to mold this information into unique structures allows designers to present a great deal of information to learners in ways that are appropriate to the content, the learners, and the context within which the learning will take place. The question then becomes one of determining appropriate and effective structures for this information.

Hypermedia Navigation Structures

One of the most important issues in hypermedia relates to how the end user will access and interact with the information stored in the hypermedia system. This requires the design of some sort of *interface*. The interface mediates between the hypermedia system and the end user. Whenever a user moves from one location in a program to another, they are said to be *navigating* the program. Navigation tools help users to direct their searches and reorient themselves if necessary. Computers have advanced so much that there are now myriad ways for learners to interact with a hypermedia system, including various forms of menus, hyperlinks, specialized input devices, and search engines. Because of the large amount of information and multimedia elements that can be included, the design of the user interface is even more important than it was for earlier forms of computer-based instruction. A properly designed interface will allow users to easily move from node to node to find what they need.

Hyperlinks allow various relationships to be established between the different nodes of information. Lowe and Hall (1999) describe two major link taxonomies that are based on the type of relationship being represented. *Structural* links provide a base structure for the information contained in the hypermedia program and can be used to provide different types of application structures, such as linear or hierarchical arrangements. These types of links are important in helping the user navigate within the information space but do not necessarily imply any semantic relationship between linked information. *Associative* links are used to link associated concepts. They allow the author of a program to indicate a semantic relationship that is independent of the specific structure of the information. In addition, they allow users of the program the ability to access the same information from different contexts. “It is these relationships - or rather the links which are a representation of the relationships - which provide the essence of hypermedia, and in many respects can be considered to be the defining characteristic” (p. 34). Associative links are also referred to as *semantic*, *cross-referenced*, *referential*, or *embedded* links.

Lowe and Hall (1999) go on to describe three key navigation structures: linear, hierarchical, and networked (see Figure 1). In a linear structure, the user navigates sequentially, moving from one node to the next. The linear approach is appropriate if the designer wants the user to visit each page in order without skipping around. This can be beneficial if one wants to retain the sequential structure of instructional content that was originally developed in printed form. In a hierarchical structure, users typically begin at a single node, or home page. This node will have links that lead to subordinate nodes; these nodes, in turn, can contain links to more subordinate nodes and/or links back to the home page. Finally, in a networked structure, non-sequential, associative links are used to relate concepts together within the information space. This allows users to navigate more freely within the hypermedia environment. In many instances, a combination of these structures is often used to form a hybrid structure; hierarchical links are often used to represent the information structure, while network links are used to represent semantic connections.

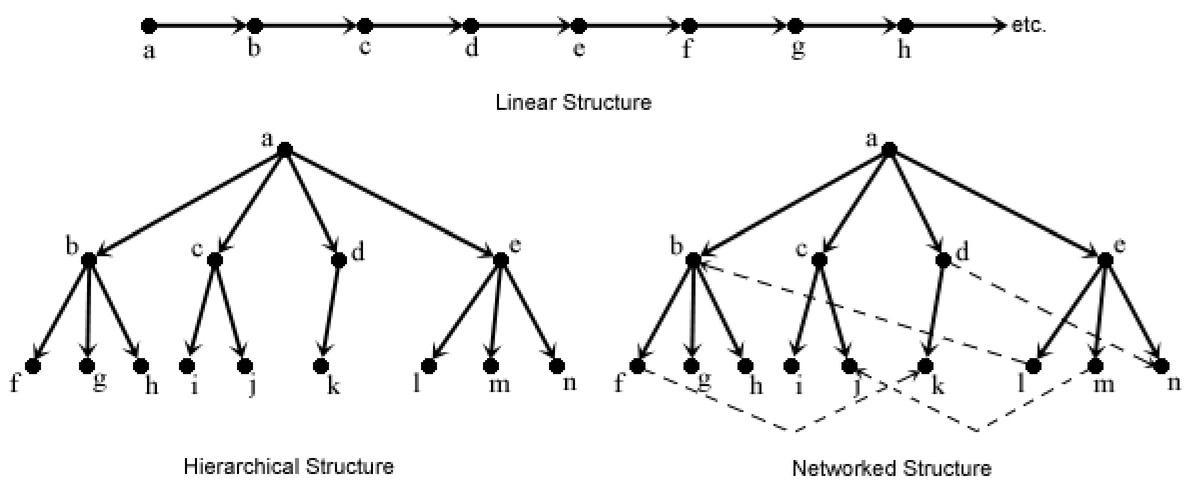

Figure 1. Three common structures of information within hypermedia environments, indicating the relationship between nodes and links. The dotted lines in the networked structure represent associative links.

On a broader scale, Gall and Hannafin (1994) describe three structures that make up a hypertext system: macro level, micro level, and control. The macro level structure includes the knowledge base that makes up the system, the interface that allows users to interact with the system, and the navigation scheme that determines how users move about in the system. The micro level structure includes the nodes and links in the hypertext system. The nodes are the organized units of information, and the links connect the nodes and define how they are accessed. The third structure, control, involves the amount of control given to learners and the function of that control.

Gall and Hannafin (1994) go on to describe four control functions: searching, browsing, connecting, and collecting. *Searching* involves an active process of seeking specific information from the system. *Browsing* involves perusing through a system without having any specific goal in mind. This allows learners to acquire incidental knowledge, which can be a positive outcome, but in the process they may overlook important information. The third control function, *connecting*, involves having learners create their own links between nodes, allowing them to turn their mental connections into physical ones. Finally, *collecting* involves having the learners select different chunks of information from the hypertext system and arrange them into a new structure.

Making effective use of these control functions requires learners to have good metacognitive skills. Metacognition involves both an awareness and regulation of cognitive processes (El-Hindi, 1993). “A high degree of metacognition is necessary for learners in hypermedia environments to create their own knowledge; to decide on the pace, sequence, and content of instruction; and to monitor and assess progress relative to their instructional goals” (Fitzgerald, 1998, p. 116). In addition, learners must have “the capacity to invoke these processes in evaluating one’s understanding, assessing learning needs, and selecting appropriate alternatives. In hypertext, metacognitive demands increase due to the limited availability of structural support normally available” (Gall & Hannafin, 1994, p. 222). Trumbull, Gay, and Mazur (1992) examined students actual and perceived uses of navigational and guidance tools in a hypermedia program. Of the four groups that emerged from the study (browse, index, guide, and mixed), students in two of the groups (guide and mixed) were generally unaware of which mode they had employed, suggesting that the subjects were metacognitively unaware of their own decisions and unable to express what they had achieved.

As described earlier, schema theory, as well as other related cognitive theories, places a great deal of emphasis for learning on prior experiences and describes learning as a uniquely individual process (Ayersman, 1993). As such, meaning is not a product of the individual or of the instructional environment but arises out of the interaction of the two. In hypermedia, links can be made between nodes of information in ways that closely resemble the links made in the human brain. These links should “facilitate remembering, concept formation, and understanding” (Kearsley, 1988, p. 23). Structural and associative links are usually predetermined for learners by the instructional designer, but in the case of more constructivist-oriented learning environments, the links can be left up to the learners to make as they explore. “Users of schema-driven multimedia environments, by nature of design, tend to be more constrained in their navigational efforts…however, with multimedia environments that are more constructivist in nature, less structure is imposed upon the content” (Lawless & Brown, 1997, p. 122).

Problems can arise when inexperienced users are given too much control over the navigation. Conklin (1987) believes that the interface is a great place to quickly drive people to cognitive overload. As the number of options and choices increase, so does the potential for users to become lost and disoriented. Learners may not know where they are, where they need to be, or how to make use of the information at hand. The paths they take can end up looking more like random walks than purposeful searches. The resulting confusion can have serious repercussions on learning. Therefore, some sort of designer-imposed navigation structure is usually necessary to promote efficiency. A well-designed navigation system lets users know where they are and how to get where they need to go (Conklin, 1987). However, the more that designers impose structural limitations on users the more they limit the ways in which learners can explore and make their own connections. Some researchers believe that there is little hope that all learners will be able to recognize the designer's cognitive structure and adopt it. Since every individual's knowledge structure is different, learners may learn best from different arrangements of information.

Myers and Burton (1994) believe that navigation options may have to change based on a user's experience levels, presumably by examining individual differences and prescribing appropriate options. Students moving from linear learning environments to nonlinear learning environments may need time and assistance to adapt to the differences. In fact, nonlinear information structures can result in reduced performance for many learners until they become comfortable and proficient with the format (Schroeder, 1994). Regardless of the navigation strategy provided, it is important that learners be made aware of what options are available to them for navigating the system. Understanding the navigation interface should help to alleviate confusion at the outset. For this reason, instructions on how to navigate the program should always be provided at the beginning of a program. In addition, learners should be made aware of how the links are associated with each other.

A study by Schroeder and Grabowski (1995) compared three types of hypermedia navigation strategies. In two of the treatment groups, students were provided with graphical concept maps that indicated links between related concepts. One of the maps merely indicated the links, while the other map provided descriptive links. In the third treatment group, the maps were replaced by linked hotwords embedded within the instructional text. The results of the study showed no significant differences between the groups. However, in analyzing the user data, the authors found that most students moved through the material sequentially and in a hierarchical fashion as opposed to moving in a conceptual or associative manner across the material. They concluded that most users explored the material in a passive manner and offered suggestions for structuring hypertext systems. Their suggestions include providing path histories, global navigation maps, indicators of the percentage of screens viewed, guided tours, and a search capability.

A study by Paolucci (1998) also used three different types of navigation strategies: conventional, branching, and hierarchy. In the conventional group, topics were linked referentially in an unstructured format so that students could access the information freely. In the branching group, students were limited to a more structured arrangement of information, although there was still some degree of openness. In the hierarchy group, students had the least amount of freedom in that they could only access information that was directly related to the current node, and had to learn lower-level skills before accessing higher-level skills. The participants were fifth-grade elementary students. Results revealed that the students in the branching (middle) group performed significantly better than students in the other two groups. It appears that, for at least this group of learners, “too much” freedom or “not enough” freedom led to a decreased level of performance and that the branching treatment provided just the right amount of control and support.

Search engines are another increasingly popular method of interacting with hypermedia systems. Search engines allow learners to create their own structures of knowledge based on the terms used in the search. The effectiveness of search engines requires that individual nodes be set up according to a classification scheme based on keywords or other attributes of the node. With the information properly categorized, users can query the system based on the topics in which they are interested. The system then presents a list of results that match each query. Users can browse the nodes and in this way structure knowledge based on their input, thus allowing them to explore information in ways that are most interesting and relevant to them. To be successful, though, it is important that learners are not only able to *find* needed information but have the skills to sift through that information and *retrieve* what is relevant to their current objective.

Marchionini (1988) found that high school students did not construct well thought out search strategies when looking for information in a hypertext system, preferring instead to follow links that they thought were most interesting. He suggests that novice users may be unable to take advantage of the richness of information that a hypertext system provides. Indeed, a search engine does not provide the type of structure inherently seen in traditional forms of instruction and may lack certain instructional events that are considered important for learning. Hill and Hannafin (1997) examined the strategies employed by adult learners in a Web-based learning environment. Factors that influenced implementation of successful search strategies included metacognitive knowledge, perceived user orientation, self-efficacy, and the level of prior system knowledge.

Leader and Klein (1996) investigated the effects of different hypermedia search tools on the performance of students in a hypermedia environment. They compared four different search methods: browser, index/find, map, and all-tools. In addition, they looked at the cognitive style of field dependence/independence. There were no significant main effects for the type of search tool used, but there was a significant interaction between search tool and cognitive style, with the field independent students performing better under the index/find and map treatments. The authors suggest that different types of navigation tools will work better with some students than with others. “Decisions about which interface tools to provide for database search and information retrieval should take into account the cognitive styles of users” (p. 13).

The effectiveness of the user interface will largely determine learners’ success. Designers can create interfaces with predetermined paths, or they can allow learners to create their own paths through the material. Jonassen (1991) states that hypertext systems “vary in the degree of explicit structure imposed upon them by the authors.…Few designers of hypertext believe that hypertext knowledge bases should be unstructured and totally nonsequential so that users would have no guidance about the information they access” (p. 85). How much structure is too much? How much is not enough? An excessive number of hyperlinks could provide a distraction to learners and interfere with the acquisition of relevant knowledge. On the other hand, strategically placed links could provide meaningful cognitive connections between different nodes of information and thus facilitate deeper processing of the material. Even beyond that, a well-linked network environment could allow learners to create their own connections that are a good fit to their individual learning styles and preferences.

Potential Problems with Hypermedia

Conklin (1987) identified two main disadvantages to hypermedia: disorientation and cognitive overload. Disorientation stems from users not knowing where they are, as well as not knowing how to get where they need to go. Hypermedia systems have the ability to foster self-directed learning, but as learners are left more on their own there is a greater chance that they will become distracted by irrelevant information. As the number of nodes and links increases, this problem worsens. On the World Wide Web in particular, the presence of numerous hyperlinks invite learners to jump to other locations that may or may not be related to what they are engaged in. If a learner strays too far, there may be no way to guarantee that they will return to the instruction.

Marchionini (1988) describes another form of disorientation stemming from the lack of feedback regarding the scope of a hypermedia program. In a large program, users may have no way of knowing how far they have gone or how far they have to go to reach the end. Compare this to a textbook, where judging one's progress is easy to determine. If you are on page 100 of a 200-page book, you know that you are halfway to the end and halfway from the beginning. In a hypermedia system, there is no inherent visual indicator of scope or progress. "The rich learning environment can easily become an environment of 'hyperchaos'" (p. 9). After just a few clicks, users can end up far from where they started with no indication of how to get back.

Cognitive overload stems from the richness of information contained in hypermedia systems and can occur when users are assaulted with more information than they can handle at one time. It can also occur when users encounter information that is not presented in a manner that allows them to make the necessary semantic associations. When hypermedia systems start to resemble networked structures, learners are required to make more decisions, and the resulting cognitive load can become overwhelming. As Jonassen (1988) states, "The exponentially greater number of learning options available to learners places increased cognitive demands upon the learners that they are often unable to fulfill" (p. 14). "These problems can be minimized—but not eliminated completely—through improved system design focusing on initial orientation, training, and on-line support" (Gall & Hannafin, 1994, p. 222).

There are two main ways of overcoming the problems of disorientation and cognitive overload. One way is to develop effective navigational tools so that users always know where they are and are given an indication of where a particular link will take them. Another way is to introduce users to the hypertext/hypermedia concept gradually. Many people are still apprehensive about using computers and should not be left to roam free through a large body of unstructured information. Users should instead be introduced to smaller, more structured systems so that they can become familiar with the process of interacting with hypermedia before they progress to larger, unstructured systems (Brown, 1997).

On the other hand, there are some who suggest that a little bit of disorientation can be good since it forces learners to work harder at making the necessary cognitive connections. Mild disorientation can excite readers, increasing their concentration, intensity, and engagement. Kahn and Landow (1993) state that expert users of hypertext systems do not always find the experience of disorientation to be stressful. Becoming a little “lost in hyperspace” can lead to something called *serendipity*, which is the accidental discovery of things that were not originally sought after (Woolf, 1981). Kahn and Landow cite examples from the literature in which disorientation is a desired effect. While beginners can find such experiences disturbing, experts may find them pleasurable. Kahn and Landow stress that disorientation arises both as a result of reading difficult material and as a result of poorly designed systems.

It is important to determine the ways in which hypermedia can be used as a cost-effective instructional tool to enhance the learning process instead of interfering with it. A balance must be struck between making sure students acquire necessary skills and knowledge and giving them the freedom to interact with information in ways that are meaningful to them. In order to avoid the problems of disorientation and cognitive overload, some sort of assistance must usually be provided to learners. This generally comes in the form of navigation structures, help menus, and/or navigation aids.

Summary & Conclusions: Hypermedia

The recent explosion of interactive technologies has made developing hypermedia materials a realistic goal for more people. Interactive systems can now be developed using the numerous authoring tools available and without the use of complex programming skills. Consequently, many educators are now attempting to develop their own materials. However, according to Hannafin and Land (1997), these advances have had little impact because few applications have unleashed the potential of either the technologies or the learners. With this in mind, the goal becomes one of developing *effective* hypermedia materials. How can hypermedia be used as an instructional tool to enhance the learning process instead of interfering with it?

Because hypermedia is still a relatively new area, there is not exhaustive research on the topic. Consequently, there is much yet to be learned about how people learn from hypermedia. Burton, Moore, and Holmes (1995) report that "many of the current guidelines for the development of hypermedia programs can be traced to assumptions, intuitions, and (apparently) common sense.…with a few exceptions, there is not a body of research on the design, use, and value of multimedia systems" (p. 364). Finishing up their review of hypermedia, Dillon and Gabbard (1998) put forth three broad conclusions. First, hypermedia affords the most benefit for specific tasks that require rapid searching through large information resources. Second, increased learner control is helpful to different users depending on their abilities. In particular, low ability users seem to have the greatest difficulty with hypermedia. Finally, differences in individual learning styles may help explain the inconclusive research results involving hypermedia. They added, "Since hypermedia may be implemented in multiple forms, those that are best suited to one style of learner may be completely inappropriate for others…a concerted research effort in this area is likely to offer considerable benefits" (p. 346).

Researchers and designers should look beyond the broad technical capabilities of hypermedia and focus on the unique attributes that will allow hypermedia to be used in creating effective instructional environments. Gall and Hannafin (1994) add:

> The power of hypertext, from a technological perspective, is apparent…. However, technological capabilities are neither the only nor the dominant factors. Hypertext learning environments are shaped by the interactive influence of the learner, the learning task, the system structures and features, and the educational setting. (p. 220)

Who is best suited to this type of learning environment? Research can help provide an answer to this question. “An examination of hypertext learning systems, learner attributes, learning tasks, educational settings, and their interactions is critical to understanding the potential of hypertext in education” (p. 229).

A further question to be answered concerns the person best qualified to make instructional decisions in hypermedia learning environments. Hypermedia systems can present integrated displays of information, allowing for self-guided and interactive learning with little or no instructional guidance. Because of the linking aspect and the ability to include many different forms of multimedia, hypermedia encourages users to interact with it in ways that previous technologies have not. Should instructional designers have ultimate power when it comes to determining what is “right” for learners in any given situation? Or, should some or all of this power be shared with the learners themselves? These questions lead to the issue of learner control.

Learner Control

In most traditional learning environments, learners have little control over how or what they are taught. In a learner-controlled instructional environment, however, individual learners can have considerable influence over what is taught, how it is taught, and the pace of instruction. Some theorists speculate that when learners are given more control and more choice they feel greater responsibility for their learning. The reasoning is that students will be more motivated to learn if they are allowed to be in control of their own learning. They can skip over material that they are already familiar with or are not yet ready to study. It is also thought that learner control helps alleviate boredom, frustration, and anxiety.

The idea of learner control has been around since before the use of computers in education (Williams, 1993). Early studies looked at self-guided instructional materials and nontraditional classroom structures. Learners were often allowed to proceed through the materials at their own convenience and pace. As computers made their way into the educational environment, the interest in learner control research became more prevalent. Indeed, the idea of giving learners more control over their learning has enjoyed increasing popularity (and debate) because of the growth of computer- and hypermedia-based instruction in the schools.

Overview of Learner Control

The term *learner control* is commonly used to refer to a design feature that allows a learner to make instructional decisions while interacting with a computer-delivered lesson (Shin, Schallert, & Savenye, 1994). Santiago and Okey (1992) describe learner control as “the presence of instructional design options which give learners the choice to make decisions, to exercise control, and to assume some amount, or even total responsibility regarding their instruction” (p. 47). The term learner control does not represent a single level of control; most studies that look at learner control vary the amount of control afforded to the learner across treatment groups. Therefore, learner control can represent a variety of learning conditions. Because various studies have looked at learner control in so many different ways, it is probably helpful to describe learner control both in terms of *categorizing* it and in terms of *operationalizing* it.

Categories are used to describe the various amounts of control that are afforded to learners. For purposes of research, treatment groups are usually referred to by one of several broad categories. There are many terms used in the literature to label these categories. The most common terms are program control, learner control, lean-plus, full-minus, adaptive, and learner control with advisement. In early computer-based instruction, the control over learning was centered in the computer itself. Students were merely carried along a prescribed linear path of information. This type of instruction worked much like a computerized book or slide show, with students being prompted to click to the next page or screen. This came to be known as *program control*. More advanced versions of program control included embedded practice and feedback exercises. As programming advanced, though, designers were able to allow learners to determine the content, sequence, and pacing of the instruction. When this happened students became more independent and personally responsible for their own learning. This type of design came to be referred to as *learner control*. These two categories are still used today as broad descriptors of instructional treatments. Program control usually refers to the treatment with less control, while learner control refers to the treatment with more control.

In addition to learner control and program control, many early studies used the terms *lean-plus* and *full-minus* to describe their treatment groups. Lean-plus is used to describe situations in which learners initially have access to a limited amount of instructional materials but are given the option to selectively add additional materials if they want. This additional information can be in the form of additional instructional content, examples, practice items, and feedback. Full-minus is used to describe situations in which learners are given access to a full range of instructional materials but have the option to selectively bypass some of them. The types of materials that can be added or bypassed by learners vary greatly between studies but frequently include additional instructional content, examples, practice items, and feedback. These two types of strategies can invoke different cognitive processes and may appeal to learners with different learning styles.

As learner control studies progressed, more advanced forms of learner control were developed that attempted to individualize the instruction even further. In instruction that uses *adaptive control,* the instruction is controlled by the computer but is adapted to each learner based on a predetermined factor. In the most basic form of adaptive control, some sort of preinstructional measure is used to tailor the instruction to each individual. This measure could be a student's prior achievement, level of prior experience, or pretest score. In the more advanced form of adaptive control, the instruction is dynamically modified based on learners' progress through the instruction. For example, if learners are progressing poorly, then they might be directed to more practice or review. If learners are progressing well, they may be given content that is more advanced. In either case, with adaptive control, the learner does not actually have any control over their progress; the computer makes decisions and adapts the instruction to each individual learner.

Similar to adaptive control is *learner control with advisement*. As with adaptive control, the computer monitors each student's progress through the instruction, but instead of automatically prescribing instructional strategies, the learner is given advice on how to approach the instruction. Advisement can include recommendations about the number of practice items to complete, content to be reviewed, or a specific sequence to follow. The learner can then choose whether to accept or reject this advice; they are not forced to follow the computer's suggestions. In this way, learners are given a greater degree of control over their progress, but are also given guidance that can help them move through the environment in an efficient manner.

Adaptive strategies select learning resources *for* students, while advisement strategies allow learners to make choices. Although these types of instructional conditions can provide powerful learning experiences, they are very costly to develop because each student's performance must be analyzed and then individual prescriptions generated that are oriented to the learning task. Studies that have looked at adaptive control have generally found that students perform better with adaptive control than with either program or learner control and that they take longer to finish than standard learner control groups (Milheim, 1990).

Learner control strategies are also often categorized as *external* or *internal*. External strategies place more of the control with the instructional program, while internal strategies place more control with the learner. Thus, program control could be considered external because control is external to the learner, while learner control could be considered internal because more control is given to individual learners. Learner control is of course not a dichotomy, as there are many control options that can be given to or withheld from learners. However, for research purposes, learner control as a variable is generally divided into two or three levels based on these categories.

While these broad categories are helpful, they do not give specifics as to how learner control is actually implemented in various studies. For example, the terms learner control and lean-plus can mean different things in different studies. Therefore, it is important to understand the ways in which learner control is operationalized within various studies. Learner control is operationalized according to how control is provided to or withheld from students within the various treatment groups. This generally involves any number of different instructional strategies or events. The main instructional elements that learners are usually given control over are the content, pace, and sequence. Control over content allows students to access or skip over instructional materials. Control over the pace allows students to adjust the speed of the presentation of instructional materials. Control over the sequence allows students to adjust the order in which content is accessed. While those are the main ways in which learner control is operationalized, many other strategies can be used. Other strategies used in learner-controlled instruction involve allowing learners to: (a) choose which topics to study, (b) choose the mode of presentation (e.g. verbal or graphic), (c) access advance organizers, (d) determine the text density, (e) choose an instructional context, (f) determine the amount of linking and interlinking, (g) access help menus and glossaries, (h) access content maps, (i) determine the number of examples seen, (j) determine the number of practice questions seen, (k) choose the amount or kind of feedback to see following practice questions (e. g., verification or elaboration), (l) determine the immediacy of feedback, (m) choose when to access review material, (n) decide when to take tests, and (o) choose when to exit the instruction.

Close examination of the strategies that are implemented in individual research studies can help us understand how learner control is operationalized and manipulated. It may be easiest to think of learner control as a continuum of control strategies, going from complete program control on the left to complete learner control on the right. On the left, learners have fewer options regarding what to do, what to study, or how to perform. Closer to the right, learners have increasing control over the sequence, content, and context of the instruction (Jonassen, Wilson, Wang, & Grabinger, 1993). The further right that learners are placed, the more they are required to construct their own knowledge. In general, strategies that fall on the left half of the continuum are referred to as program control, while strategies that fall on the right half are referred to as learner control. The program control groups often include some sort of adaptive aspect in that the program adapts to the individual learner as they progress without providing the learner any extra control. The learner control groups often include varying amounts of advisement offered by the computer, with the learner able to choose whether or not to follow the advice. Where should learners be placed on this continuum? How should this placement be determined? Numerous studies have attempted to answer these questions.

Learner Control and Individualized Instruction

Learner control allows the instruction to accommodate the learner as opposed to having the learner accommodate the instruction (Friend & Cole, 1990). In addition, learner control encourages learners to take a more active role in the learning process. Even before computers saw widespread use in educational environments, O'Neal (1973) hailed learner controlled instruction as a means for developing the self-directed learners required by today's society. Early research in learner control looked at various learner control options to see if learners performed better with more control as opposed to less control. Most researchers expected to discover that learners given more control perform better. However, the results did not overwhelmingly support this assumption. Later, a shift occurred in that researchers began to investigate how the various methods of learner control interacted with various learner characteristics. It may be that learners differ with respect to how much they like having control over instruction, how well they perform under high-control conditions, and how they use their skills in such conditions. Snow (1980) suggests that if certain abilities or individual characteristics are shown to predict improved performance under learner control conditions, students can be differentially granted more control over the learning environment. While some learners might benefit from having increased control over their learning environment, other learners might benefit by having limited control. Reed and Oughton (1997) suggest that students with different learning styles, ability levels, and prior knowledge differentially prefer using linear and nonlinear paths in hypermedia systems.

Learner control fits better with the constructivist view of learning because it encourages the individual mental processes required in order for students to construct complex mental structures. Bruner (1973) stated that learning takes place when people actively select, retain, and transform information. Bruner and other cognitive theorists believe that if learners are able to help direct their learning processes, they will be more likely to select, retain, and transform pertinent information. For Shank (as cited in Large, 1996), good instruction is active, not passive. “Students ought to be doing something, not watching something” (p. 97). Learners given more control over their learning environment are more likely to think about what they are doing and thus generate more mental processing as they attempt to make sense of the content they are accessing. Consequently, the knowledge structures they construct are more likely to be personally meaningful to them. In addition, serendipitous learning may occur; students may learn incidental information that was not intended by the designer, which can lead to new connections being made between chunks of information.

As technology develops, the computer is becoming a major tool in the presentation of instructional systems. Early control strategies were rather limited, but the increase in hypermedia-based instruction has led to many more choices being available to learners. Information can be presented in any sequence, and learners can be given complete control over how they access that information. More flexible hypermedia environments allow learners to chart their own paths through a set of instructional materials. They can follow paths and links set up by designers or set out on their own in accordance with their own needs and desires (Large, 1996). They are no longer constrained to hitting the “next” or “back” buttons. At the same time, however, these nonlinear structures of information may not have the coherence that is provided by the designer when information is structured in a linear way. This problem is compounded in Web-based learning environments, where the learner is potentially only one click away from leaving the instructional environment. Too many hyperlinks can provide a distraction to learners, while at the same time strategically placed links can provide meaningful cognitive connections between different nodes of information and thus facilitate deeper processing of the material.

Learner Control and Academic Achievement

As computers have improved in their ability to provide feedback and interactivity, it has become easier to provide learners with more control during the instructional process. Although learner control seems to be intuitively appealing, how much should be granted, to whom it should be granted, and under what conditions it should be granted are questions that should be answered before handing over the keys to learners. By considering these questions, designers can make sound decisions when planning instructional events. Researchers have attempted to answer these questions in numerous learner control studies that have been carried out over the years. As the following sections will show, the results of these studies have been inconclusive; some research indicates that individuals perform better when given control over their instruction; other research indicates that individuals perform worse. Still others have found no significant differences between the two. A more complete summary of studies on learner control and academic achievement can be seen in Appendix A.

Control over content. In many learner control studies, control is given to learners by allowing them to choose whether or not to view extra content. In some cases, learners are given the option to access review material after missing practice items. In other cases, this may involve the viewing of extra instructional content. Kinzie, Sullivan, and Berdel (1988) looked at learner and program control of content review using eighth-grade science students. The program control students were *required* to review content after missing a practice item, while the learner control students had *a choice of* reviewing content after a missed item. In both cases, students were required to respond to practice items until they correctly answered them. The results showed that students in the learner control group performed significantly better on a posttest than students in the program control group. The authors suggest that the strategy of requiring all students to correctly answer practice items, in addition to the informational feedback, was enough to mediate the effects of the learner control students skipping the content review. In several other studies in which learner control students did not perform significantly better than program control students, the learner control students were allowed to move on after missing practice exercises and not required to answer them correctly.

Campanizzi (1978) also investigated learner control versus program control of content review, this time in a computer-assisted instructional program designed for college students. As in the previous study, students who missed embedded practice exercises were either given the option to review the associated material (learner control) or required to review the associated material (program control). The results indicated that the achievement of students in the learner control group was significantly greater than the achievement of students in the program control group. In addition, even though they had greater achievement, students in the learner control group actually received the review material significantly fewer times than the program control group. The author suggests that because learners were given a more active role in the learning process they perceived the material to be more meaningful. Regardless of the interpretation, these results are interesting because the difference between the two treatment groups was minimal, indicating that small variations in instructional strategies can have significant effects on learners. Instructional strategies such as these can be implemented with minimal effort from designers and teachers. In contrast, a similar study by Schloss, Sindelar, Cartwright, and Smith (1988) found different results. As before, learner control was determined by either requiring learners to view additional information after an error or giving them the choice to view the additional information. However, unlike the previous studies, there were no achievement differences between the groups, even when students were differentiated by ability level. However, students in the learner control group finished more quickly.

Studies that use lean-plus and full-minus treatment groups also involve learner control over the content. Hicken, Sullivan, and Klein (1992) explored the use of lean-plus and full-minus learner control treatments. In addition, they looked at different learner incentives. Participants in one incentive group received class credit just for participating in the study, while students in the other incentive group were told they had to score at least 70% on a posttest to receive credit. There were no significant posttest differences between the learner control groups, but the performance-incentive groups scored significantly better than the task-incentive groups.

In most studies, the terms full and lean are used to refer respectively to the learner control and program control treatment groups. However, a study by Hannafin and Sullivan (1995) examined learner control and full and lean methods as separate strategies. Students in the two program control groups had no choice over the material in full and lean versions of the instruction. Students in the learner control groups could either add material in the lean version or bypass material in the full version. Ninth- and tenth-grade students were the participants. The results revealed no significant differences between the full and lean groups, but there was a significant difference between the learner control and program control groups. Students in the learner control group performed significantly better than did the students in the program control group. Schnackenberg (1997) also looked at the interaction between learner control conditions and program modes in a computer-based instructional program. In the “full” mode there were 240 screens, while in the “lean” mode there were 196 screens. Students in the learner control group had the additional option of adding screens to the lean version or skipping screens in the full version. Unlike the Hannafin and Sullivan study, the results showed that students receiving the full program performed significantly better than those receiving the lean version, while the learner control options had no significant effect. The author attributes the differences to the fact that students in the full group viewed significantly more practice exercises, even when given the option to skip exercises.

Control over sequencing. Sequencing is another area in which students are commonly given some measure of control over their instruction. With sequence control, students are allowed to adjust the order in which content is accessed. Gray (1987) looked at two different methods of controlling the sequence of instruction. In the learner control group, students were able to make decisions regarding how they accessed the exercises, while the computer-controlled group followed a linear path. Students under learner control performed significantly better on a test of immediate recall but not on a delayed retention test given a week later. In addition, students in the learner control group had negative attitudes toward the instruction. The author suggests that too much control is a distraction for learners and can keep them from attending to the necessary information. Another study by Gray (1989) looked at two levels of control over branching in a computer program. The results of this study indicated that students given less control over branching performed the best on both a retrieval task and a retention test. These two studies by Gray demonstrate that the “correct” amount of control to provide to learners may not be clear-cut. There appear to be a variety of factors that must be considered when dealing with learner control.

Milheim (1990) studied the interactive effects of pacing and sequencing with 99 students in an interactive video program dealing with the topic of photography. Student control of pacing was achieved by allowing students to determine how long they spent on each screen; student control of sequencing was achieved by allowing students to choose the order they accessed the lessons. Learner control with regard to pacing proved to have a significant effect on achievement on both a posttest and a delayed retention test; learner control of sequencing did not result in any significant differences. The author suggests that giving learners control over the pacing may make them feel more in control, while control over sequencing does not. An alternative conclusion might be that students should be given even greater control over sequencing to determine if there are any differences to be found.

A study by Coorough (1991) examined sequence control along with control over review. College students who participated were assigned to one of three treatment groups that varied in the amount of control afforded to learners. Students in the program control group followed a fixed sequence, and after missing a practice activity they were automatically branched to a review section. Students in the learner control group controlled the sequence, choice of practice activities, and branching options. Students in the advisement group received suggestions from the computer at decision points. The results showed no significant achievement differences between the groups. Coldevin, Tovar, and Brauer (1993) also presented college students with three levels of control and found that students with the least control (linear) significantly outperformed those who were given more control. They suggested that learners who are given more control over their instruction but do not possess an adequate amount of prior knowledge in the area will be ill-prepared to make appropriate choices in the open environment. “Given full control over instruction without the commensurate prior knowledge, learners may choose inappropriate or illogical paths, either as a function of preference or simply because they do not know better” (p. 125).

Tovar and Coldevin (1992) compared three levels of learner control (linear, mixed, and learner) along with two levels of orienting activities (orienting and no orienting) in an interactive video lesson. The results showed that students in both the linear and mixed groups performed significantly better on a posttest than students in the learner control group. These findings conflict with the results of a study by Hannafin and Colamaio (1987) in which students in both the learner control group and the learner control adaptive group performed better than students in the linear group. However, in the Hannafin and Colamaio study, students in the linear control group were not able to review material on the videodisk after missing a practice activity, whereas in the Tovar and Coldevin study the linear students were *required* to review the material. It appears that the required review may have positively affected the results for the linear students. This once again suggests that minor differences in the way learner control is operationalized can have a significant impact on research results.

Control over practice. Several studies have examined the effects of giving learners control over practice and feedback. An early study by Fredericks (1976) looked at learner control over practice in a computer-assisted instructional environment. The two treatments were classified as program control and student control. The treatments differed in how practice was assigned by the computer and the amount of practice that was required. Results indicated no significant differences in performance between the two treatment groups, although the students in the student control group had a significant time savings over students in the program control group. The author suggests that even if learner control does not produce significant advances in achievement, it may be a welcome strategy if the time required to master a subject can be reduced.

Pollock and Sullivan (1990) examined the effects of learner control and type of practice exercises on the achievement and attitudes of seventh-grade science students. The learner control groups differed in whether or not students had to complete embedded practice exercises. The types of practice exercises were recognition (multiple choice) and recall (short answer). Students in the program control group (received all practice exercises) performed significantly better on the recognition portion of the posttest but not on the recall portion. In addition, students who received recall-type practice exercises performed significantly better on the recall portion of the posttest, while there were no differences on the recognition portion of the posttest. The results give limited support for the use of program control and recall-type practice exercises. Because program control in this case involved students viewing 21% more practice exercises, the authors suggest that the amount of practice is an important aspect of instructional design and that learners who are given control over the number of practice items they access may not perform as well if they elect to choose significantly fewer items than are available.

Ross, Morrison, and O’Dell (1989) allowed college students to choose a context for the practice problems that were presented to them. Students who were allowed to choose the context elected to receive significantly more examples than students who were not allowed to choose the context. However, the results showed no significant benefits to learning. The authors suggest that the insignificant results may stem from the contexts being too simple or from the context manipulations being limited to practice items only and not the instructional presentation. In a similar study, Morrison, Ross, and Baldwin (1992) crossed five context conditions with three instructional support conditions using a computer-based mathematics unit and a sample of sixth graders. The five contexts were “animals,” “sports,” “clothing,” a no-context condition, and a learner-control condition. The three support conditions varied in the number of practice items presented, with the learner-control group having the option to take from one to four items each time. Once again, there were no significant results for the context groups. However, there was a main effect for the support conditions, with students in the maximum support group (received all practice items) performing significantly better than students in the learner control support group. Further analysis of the results indicated that the students in the learner control group chose to view very few additional items.

Control over feedback. Allowing students control over the amount and types of feedback has generally not been an effective control strategy. Pridemore and Klein (1992) compared two levels of learner control and type of feedback in a computer-based program used by 100 college students. Learner control was based on access to feedback; students were either forced to view feedback or given the choice to view feedback. Feedback types were verification, in which students were simply told if their answer was correct or not correct, and elaboration, in which students were given a short explanation after each question. The results showed that the level of learner control did not have a significant effect on posttest achievement but that students given elaborative feedback performed significantly better on the posttest.

A follow-up study conducted by the same authors (1993) included a third feedback type in which students were given only the correct answer without the short explanation. In this study, the program control group performed significantly better than the learner control group. Once again the results showed that students given only verification performed significantly worse than those given answer-only or elaborative feedback. It may be that having an extra treatment group of students that was required to receive feedback had an influence on the overall scores for the program control group. Finally, Hines and Seidman (1988) also compared different types of feedback in learner controlled instruction. They used no feedback, immediate feedback, and delayed feedback groups, as well as program control and learner control groups. There were no significant differences between any of the groups.

Adaptive control and learner control with advisement. Adaptive instruction and instruction that incorporates some sort of advisement have both had positive effects on student performance. Ross and Rakow (1981) looked at adaptive strategies used within a self-instructional mathematics program. In the adaptive treatment, practice exercises were presented to each student based on individual pretest scores. In the learner control treatment, learners were able to choose the exercises they viewed. Finally, in the nonadaptive treatment all students received the same exercises. The results supported the hypothesis that the adaptive treatment was superior to both the learner control treatment and the nonadaptive treatment on a posttest and a retention test. The authors suggest that adapting the allocation of examples to individual learners can produce higher and more stable performances.

Arnone and Grabowski (1992) examined three levels of learner control using an interactive video lesson with first and second grade students. One hundred and one first and second graders were distributed into three sets of learning conditions: program control, learner control, and learner control with advisement, along with one control group. Under program control, students moved through the material in a linear fashion. Under learner control, students made choices regarding the sequence, practice items, and review. Under learner control with advisement, students again had control, but they were additionally given feedback regarding the decisions they made. It was hoped that the advisement strategy would help younger learners, who might not have had refined cognitive abilities, perform well in an environment that allowed them more control over their learning. The results indicated that students in the learner control with advisement group performed significantly better than students in the learner control group, suggesting that the advisement strategies were effective. There were no differences between the program control group and the two learner control groups.

Murphy and Davidson (1991) used adaptive and advisement groups to find out the effects on concept learning and long-term retention. In the learner control group, students had full control over access to practice exercises and a posttest. In the adaptive group, the computer determined the number of exercises and advanced students to the posttest when they had reached mastery. In the advisement group, the students had full control, but the computer advised them on their progress. The goal was to teach concepts as opposed to facts. Results indicated that there were no significant differences between the groups on the posttest or long-term retention tests. In contrast, an earlier study by Tennyson, Park, and Christensen (1985) found that students in an adaptive group performed better on a retention test.

Shyu and Brown (1995) examined learner control with advisement and its effects on the achievement of a procedural skill using videodisk instruction. In the program control group, students progressed through the instruction in a linear order, while in the learner control group students were provided with a menu and allowed to choose their order. The subjects in the learner control group were also advised as to the suggested path to take through the instruction. Results showed that the subjects in the learner control group performed significantly better on the procedural skill. In addition, subjects in the learner control group had a more positive attitude toward the instruction. Similar results were obtained in an earlier study by the authors (Shyu &

Brown, 1992), except that attitudes were not significantly different. The authors suggest that learner control is superior for the learning of procedural tasks, presumably because of the ability for students to view the material multiple times and practice their metacognitive abilities.

Prior knowledge. One of the major determinants as to how well students do in a learner control environment appears to be the amount of prior knowledge they have. Goetzfried and Hannafin (1985) looked at three forms of learner control in computer-assisted instruction. The three treatments were externally controlled adaptive, learner controlled with advisement, and linear control. Their dependent variable was mathematics rule learning. Using low-achieving seventh grade students as subjects, they reported no significant differences by learner control condition. However, prior achievement as measured by a pretest significantly affected performance, with the “below average” students performing better than the “low” students (in this case, “low” was lower than “below average”). In addition, the linear control group took significantly less time to finish the lesson. In conclusion, the authors suggest that low achieving students may not be able to take advantage of the benefits afforded by increased learner control.

Rowley, Miller, and Carlson (1997) conducted a study using the R-WISE (Reading and Writing in a Supportive Environment) software and two levels of learner control: “guided” (low control) and “open” (high control). They wanted to find out if prior knowledge helped students in the open mode perform better. All students first used the software in guided mode, then split into the guided and open groups. There were 1277 high school students involved in the study, and the results indicated that students in the open group performed significantly better on posttest measures. The authors suggest that future instructional designs should provide a gradual transition from computer control to student control, perhaps based on student performance.

Relan (1995) attempted to overcome the sometimes ineffective choices and poor achievement of students involved in learner controlled instruction by providing training in learning strategies prior to the instruction. In addition to the strategy training, there were two levels of learner control, classified as “limited” and “complete.” These groups differed in the number of practice items offered. The results indicated a significant interaction between learner control and training type. Students in the limited learner control group performed best on an immediate posttest after being given strategy training. However, similar effects did not appear when the students were given a retention test ten days later.

A study by Gay (1986) examined how college students with different levels of prior conceptual understanding of a topic interact and learn from computer-assisted video instruction when given varying levels of learner control. In the program control group, students controlled only the pacing of the lesson. They were also provided with diagnostic feedback. In the learner control group, students had control over the pacing, sequencing, presentation mode, and amount of practice. The results indicated a significant interaction between learner control and prior knowledge. Students with low prior knowledge in the learner control group had significantly lower posttest scores than students in any of the other groups. Students with high prior knowledge performed equally well under both program and learner control conditions. These results support the belief that students with low prior knowledge of a topic may not perform well in when they are given a high level of learner control. Students with high prior knowledge seem to do equally well regardless of the amount of control they are given.

Individual learner characteristics. The inconsistent results in studies involving learner control have been attributed to several factors, including a variety of learner characteristics. Studies have shown that many learner characteristics have a positive or negative affect on students' performance in a learner-controlled environment. Carrier and Williams (1988) examined task persistence along with three levels of control: one learner control treatment and two program control treatments. In the learner control treatment, students were allowed to choose various types of elaborative material. In one program control treatment, students were required to review the elaborative material, while in the other program control treatment there was no elaborative material. Results indicated that the high-persistence group performed best under learner control, while the medium-persistence group performed best under program control.

Several studies have been conducted using the cognitive style of field dependence-independence. Yoon (1993) examined learner control and field dependence-independence in a study that involved elementary school students. There were three learner control groups in this study: program control, learner control, and learner control with advisement. The results revealed a significant interaction between learner control and cognitive style. The field independent students performed significantly better in the learner control and learner control with advisement groups, while the field dependent students performed significantly better in the program control and learner control with advisement groups. There were no significant main effects. Other studies have shown nonsignificant results using field dependence-independence. For example, a study by Daniels and Moore (2000) found no main effects or interaction effect using field dependence-independence and two levels of learner control.

Burwell (1991) examined learner control and field dependence-independence and found unexpected results. In the study, college students interacted with a videodisk-based astronomy program. The two learner control groups differed in the way students accessed the information in the program. The results showed no significant main effects, indicating that the level of learner control made no difference. However, there was an unexpected interaction. Field independent students performed significantly better in the program control group than they did in the learner control group, while the field dependent students performed significantly better in the learner control group than they did in the program control group. The authors attribute these contrary results to the fact that the time on task of the field dependent learners was greater that that of the field independent learners.

Young (1996) examined learner control and self-regulated learning strategies. The results indicated that seventh-grade social studies students with a low level of self-regulated learning strategies performed significantly worse in a learner control group than in a program control group. Students with a high level of self-regulated learning strategies performed the same in either control group. The results suggest that students receiving learner-controlled instruction need to be able to manage their learning needs as they progress through the instruction. Similar results using learner control and self-regulatory skills were found in a study by Eom and Reiser (2000). However, McManus (2000) found no significant results when comparing self-regulatory skills, advance organizers, and different levels of control in a Web-based hypermedia environment. The results were so close to significant, however, that the author suggested more research in these areas. Kinzie (1990) considers learner control, self-regulated learning, and the continuing motivation to learn to be interconnected and mutually supporting. Learner control can help develop self-regulated learning, which in turn can help promote perceptions of personal control and lead to continuing motivation.

Other individual variables have been shown to impact learners' performance in computer-assisted learning environments. A study by Freitag and Sullivan (1995) examined learners' preferred amount of instruction and found that adult learners who received an amount of instruction that matched their preference performed significantly better than subjects who received an amount of instruction that was opposite to their preference. Additionally, subjects in the full control group performed better than did subjects in the lean group. Other variables that have been examined include achievement, motivation, gender, and anxiety (Clark, 1984; Coorough, 1991). Still other variables may hold promise for learner control research. In reviewing over 70 studies involving learner control, Williams (1993) states that conclusions about “the relative effectiveness of ‘learner-control’ versus ‘program-control’ are equivocal. Across these studies, however, are strong suggestions that a number of individual learner differences can greatly contribute to both the choices students make and to the effectiveness of those choices” (p. 2).

Learner Control and Hypermedia

The computer has now become a major tool in the presentation of instructional systems. One of the often-touted benefits of hypermedia is the ability to provide increased amounts of learner control. With hypermedia, designers are no longer limited to linear-based instructional programs. They can create learning environments in which information can be presented in any sequence, and learners can be given complete control over how they access that information. However, the very ease with which learners may navigate hypermedia environments may lead them to be exposed to resources that have minimal learning outcomes (Jacobson & Archodidou, 2000). Because hypermedia involves these non-sequential and dynamic structures of information, learner control is always a relevant issue. While the power of hypertext and hypermedia instructional systems would appear to lie in users being given complete control of the use of the system, current learner control research would seem to indicate that this is ineffective; however, this issue has to be re-considered from a hypertext/hypermedia perspective.

“It is unclear whether the volumes of research in learner control are directly applicable to hypertext” (Gall & Hannafin, 1994, p. 222). Indeed, because hypermedia is an advanced form of computer-based instruction, much of the earlier learner control research involving computer-based instruction is likely relevant to hypermedia learning environments. However, the advanced capabilities of hypermedia present researchers with new areas to study.

There have been a limited number of studies that have examined learner control within a hypermedia environment. Much of the research on learner control has encompassed the allowance of a somewhat restricted freedom of movement between chunks of information. However, hypermedia allows a greater freedom of movement and can facilitate the creation of connections or links within a large database of information; in this way, the learner can become actively involved in building the learning environment. It therefore seems counterintuitive to present learners with a large amount of interlinked information and then only allow them to access it in a linear manner. Nelson and Palumbo (1992) describe three ways of categorizing hypermedia systems: knowledge presentation, knowledge representation, and knowledge construction, each differing in the amount of control given to learners. With knowledge presentation, information is presented to learners in predetermined arrangements. These systems closely resemble the traditional classroom method of instruction, as less emphasis is placed on the linking aspect of hypermedia, and the learner is more passive. With knowledge representation, more emphasis is placed on the associative links between networked information, and learners are encouraged to explore. With knowledge construction, learners are able to construct their own nodes and links in the process of constructing knowledge.

There are no clear-cut boundaries between studies that examine learner control in a computer-based instructional environment and studies that examine learner control in a hypermedia environment. However, the following studies specifically mention hypermedia or obviously use hypermedia instructional materials.

A study by Burke, Etnier, and Sullivan (1998) found no significant differences between the achievement of fifth-grade students assigned to learner and program control groups when using a hypermedia program. The groups differed regarding the sequencing of the instruction, with the learner control students being allowed to move freely within the program and the program control students being limited to a linear path. Another study that examined learner control in a hypermedia environment (Shin et al., 1994) concluded that second-grade students with a low level of prior knowledge performed better in a limited-access hypermedia condition as opposed to a free-access condition. Students with a high amount of prior knowledge performed equally well in both conditions. In addition, the presence or lack of advisement had no significant effect on the results. The results suggest that younger learners can perform well in a learner controlled hypermedia environment if they have sufficient prior knowledge.

Lanza and Roselli (1991) compared a computer-based environment featuring a low level of learner control with a hypermedia environment featuring a high level of learner control. There were no significant differences between the groups, but the hypertext group exhibited greater variability in achievement scores, prompting the authors to conclude that hypertext might be better suited to students with more ability. Indeed, the greater variability of scores in the higher-control environment could be attributed to many individual characteristics. Quade (1993) also compared a linear controlled, computer-based tutorial with a learner controlled, hypermedia-based tutorial. Students in the linear group could only move through the instructional material in a linear fashion, while students in the hypermedia group had the added option of using a graphical navigation map. As with many previous learner control studies, there were no significant differences in performance on a posttest.

A study by Yeh and Lehman (2001) looked at learner control, advance organizers, and student ability within a hypermedia environment dealing with English as a foreign language. Students in the learner control group could move through the instruction at will, while students in the program control group had almost no control; even the pacing was controlled by the computer. It was hoped that the inclusion of advance organizers would help orient students within the hypermedia environment and provide them with strategies for learning. As could be expected due to the computer-controlled pacing, students in the learner control group performed significantly better than students in the program control group. In addition, the advance organizer group also performed significantly better.

McGrath (1992) compared four versions of a mathematics program: a hypertext version, a CAI version, a no-menu version of CAI, and paper-based materials. Using teacher education students, there were no significant achievement differences between the learner control groups or between high- and low-ability students. Closer inspection reveals that the CAI and hypertext groups appeared to be similar in the amount of control afforded to the learners. Finally, a recent study by Paolucci (1998) examined the possible interaction between cognitive style (active or reflective) and knowledge structure in a hypermedia environment. The term *knowledge structure* was used as simply another way of describing three various levels of learner control. Results indicated that students performed best when given a moderate amount of control. Students in the two extreme groups became either bored (less control) or distracted (more control). Results also showed no significant relationships between cognitive style and knowledge structure. The author concludes by warning against the creation of learning environments that are too unstructured.

Although there have been many studies examining learner control in computer-based instruction, few have taken advantage of the unique characteristics of the hypermedia environment. The ones that have do not provide educators with conclusive results regarding effective control strategies. Research on these topics is important because today's hypermedia-based learning environments allow for a much wider range of control options than yesterday's computer-based learning environments, which were often limited in the number of control options available.

Learner Control and Time on Task

Many studies have found that students in learner control groups spend less time interacting with instructional materials than students in program control groups (Eom & Reiser, 2000; Fredericks, 1976; Simsek, 1993; Williams, 1993). Hicken, Sullivan, and Klein (1992) found that students using a lean version of a computer program spent more time in the program than students using the full version did. In addition, Hananfin and Sullivan (1995) and Schnackenberg (1997) reported that higher ability students using a lean version of a computer program chose to view optional elements significantly more than low-ability students did. Some researchers thus conclude that even if achievement is the same, learner control is better because of the shorter time on task. One study of self-paced instruction found that students learned the same amount in 20% to 50% less time than when instructed in a conventional manner (Kulik & Kulik, 1991).

Not all studies agree, however. In some studies students in program control groups spent less time on task (Freitag & Sullivan, 1995; Goetzfried & Hannafin, 1985; Hannafin & Sullivan, 1995; Kinzie, Sullivan, & Berdel, 1992; Yoon, 1993), whereas in other studies there were no time on task differences reported between learner control and program control groups (Hicken et al., 1992; Young, 1996). Kinzie, Sullivan, and Berdel (1988) and Kinzie and Sullivan (1989) found that students in learner control instruction who chose to bypass instructional options spent a similar amount of time in the program as students who were required to see all of the instruction. In many cases students who spent less time interacting with the materials performed poorly in achievement measures (Ross & Rakow, 1981). It is thought that learners who are given more control may spend less time on task because they elect to skip over important material. In addition, students in learner control groups that include advisement may take longer to complete the instruction because of the additional cognitive processing required (Coorough, 1991; Milheim & Azbell, 1988).

Problems with Learner Control Research

There have been conflicting results in studies concerning learner control. Most researchers had hoped to discover that learners given more control perform better, and in many studies this has been the case. However, in some studies, giving learners total control has often resulted in lower achievement, while the students given the least amount of control performed the best (Steinberg, 1989). In other studies, there have been no significant differences between learner control and program control groups. Why have there been so many inconsistencies? There may be several reasons.

A look at the ways in which learner control is operationalized in various studies may reveal some reasons for the discrepancies. The differing results of learner control studies are likely a function of the degree and types of learner control made available to learners. Indeed, as stated earlier, learner control can take *many* forms within an instructional environment, including control over the content, control over the pacing and sequencing, and control of practice and review. For example, *program control* can mean complete control by the computer, it can mean a linear version of a program in which students are forced to view all available instruction, or it can mean a “lean” linear program in which students do not view all available instruction. In a study by Yeh and Lehman (2001), program control meant no control, even over pacing. It seems unlikely that having the computer control the amount of time students view a screen of information will result in improved performance. In this case and others, the ways in which program control (and learner control) is operationalized can have a major effect on the results of the study. Researchers vary greatly on how they define learner control in their studies. As Reeves (1993) points out, “The ‘control of what’ question is a critical one if we ever wish to have any meaningful impact on the design of CBI” (p. 41). Because of this, it is unrealistic to make blanket statements concluding that learner control, program control, or learner control with advisement is “better” than the others are.

In addition to confusion regarding the operationalizing of learner control, many of the incongruent results regarding learner control and achievement can probably be explained by the small differences in the amount of control given to learners across these studies. In some studies, the differences between program control and learner control treatments were minimal. If one were to look at the continuum of learner control that ranges from no learner control (program control) to full learner control (learner control), many of the treatments used in previous studies would fall within a small range on the continuum. Even early studies that made frequent use of the seemingly broad terms program control and learner control often used treatments that only differed from each other in small ways. After all, allowing learners the option to view four practice exercises as opposed to one practice exercise hardly constitutes a major swing in learner control. In several studies, students were either forced to retake practice questions that were missed (program control) or given the choice of retaking the practice questions (learner control).

This is a very small amount of control to give to learners, so it is no wonder that there are often no significant differences in outcomes.

Goforth (1994) also describes a *ceiling effect*, which happens in studies in which the subjects in a learner control condition cannot be expected to do any better than subjects in a program control condition because they have the *choice* of seeing information that subjects in the program control group are *forced* to see. There is no extra information for them to optionally view, and thus no potential greater experience. Therefore, they cannot be expected to have significantly greater achievement. In these cases, a non-significant difference in achievement could be considered a success for the learner control condition.

It might be better to refer to some of the differences in learner control levels as being differences in *instructional strategy* as opposed to differences in *learner control.* It is more important to look at the specific strategies employed within these learner control conditions to determine which strategies can be effectively employed within instructional environments in which learners are given increased amounts of control over their learning. Ross and Morrison (1989) state, “Learner control is not a unitary construct but rather a collection of strategies that function in different ways depending on what is being controlled by whom” (p. 29). In the end, it may be better to view learner control as a broad category comprising a wide range of smaller instructional strategies.

Problems in studies may also arise due to certain characteristics of the learners. According to Steinberg (1989), learners who are beginners in a subject are usually lacking two skills that are important to be successful with learner control. First, they lack the ability to discriminate between relevant and tangential information. Second, they lack subject-specific learning strategies. In reviewing the research on learner control, Williams (1993) reported that many of the researchers stated that learners did not know how to utilize appropriate strategies when they were left on their own. Learners often do not know how to make appropriate choices or lack sufficient background knowledge or computer experience. It is also possible that providing learner control can interfere with the learning process. Having to stop and ponder the available choices can break the flow of learning.

Questions have also been raised as to whether or not students possess sufficient prior knowledge and experience to make effective decisions when given increased control (Hannafin, 1984; Ross & Morrison, 1989). Many of the studies that examined learner control and prior knowledge found that students with high prior knowledge performed better in learner control environments than students with low prior knowledge. Students who were poor performers in the subject area in question usually learned the least amount, while high performers were more likely to be able to manage their own learning (Seidel, Wagner, Rosenblatt, Hillelsohn, & Stelzer, 1978). When the learning task is relatively difficult or student ability is low, learners may want to select less instructional support so they may get out of the task sooner (Carrier, Davidson, & Williams, 1985; Ross & Rakow, 1981).

There are numerous problems with the research on learner control. Many of the inconclusive research results likely stem from these problems. It is interesting to note that back in 1974, Judd, O'Neil, and Spelt identified three potential problems with learner control literature:

1. Lack of consensus on the definition of learner control.
2. No general agreement of factors to be varied under learner control.
3. Rarely any effect on learning from the manipulated learner control variables, probably because of confounding by other variables.

It appears that these problems still plague the research on learner control.

Summary of Learner Control Research

Carrier and Williams (1988) sum up the research on learner control: “As a whole, these findings present a montage of inconsistencies, contradictions, and caveats” (p. 286). Niemiec (1996) reviewed the effects of learner control in computer-assisted instruction based on literature reviews and a meta-analysis of 24 qualifying studies. Results suggest that learner control has little if any effect on students. McNeil and Nelson (1990) performed a meta-analysis of 63 studies involving interactive video instruction and found that in general program control appeared to be more effective than learner control. In fact, a study by Rojewski, Gilbert, and Hoy (1994) found that students were more comfortable and preferred the structure and linear style of drill and practice methods to the more flexible nonlinear hypertext. Steinberg performed two analyses of learner control research, one in 1977 and another one in 1989. In both cases, she concluded that for the most part, students learned less when given control over instructional sequence. High performers in the subject area were most likely to be skillful managers of instruction. In addition, students were not very proficient at selecting exercises at appropriate difficulty levels. Finally, while there appeared to be motivational benefits to learner control, those benefits were not accompanied by better performance.

Williams (1993), summing up his review of 70 learner control studies, concluded, “Learner control should be better than program control; however, students left on their own do not uniformly make good use of such strategies” (p. 9-10). Large (1996) cautioned that that while hypertext gives learners the means to access information flexibly and individually, designers should exercise caution in allowing the learner too much control. Research has shown that students who are given control over the learning environment have trouble planning routes that lead them to desired information and thus take longer to find that information. It therefore does little good for designers to give learners control if they do not know how to take advantage of it. “These negative findings may occur because many students, especially low-achievers, lack the knowledge and motivation to make appropriate decisions regarding such conditions as pacing, sequencing of content, use of learning aids, and amount of practice” (Chung & Reigeluth, 1992, p. 14). Successfully utilizing systems containing large amounts of information requires advanced problem solving strategies for selecting, organizing, and evaluating information.

One conclusion that can be drawn from the literature is that low achieving students lack the knowledge and motivation to perform well under conditions that provide a high degree of learner control. Alternatively, high-ability students perform better with more learner control (Kinzie et al., 1988; Singhanayok & Hooper, 1998) and are more likely to avail themselves of additional material provided in lean-plus instructional conditions (Hannafin & Sullivan, 1995). Ross and Morrison (1989) concluded that high achievers seem capable of using most forms of learner control effectively. However, low achievers are less successful when given types of control “that require them to make decisions about *instructional* properties of a lesson (i.e., what, how, or how much information is taught) than from those involving variations in *presentational* aspects (how information is formatted or delivered)” (p. 29).

Numerous studies have also shown that students with more prior knowledge about a topic will perform equal to or better under higher control conditions than learners with a limited amount of prior knowledge (Coldevin et al., 1993; Gay, 1986; Goetzfried & Hannafin, 1985; Ross & Rakow, 1981; Shin et al., 1994). Students with high prior knowledge have the ability to distinguish between relevant and non-relevant information and also have a repertoire of subject-specific learning strategies to call on (Steinberg, 1989). Lee and Lee (1991) found that students with a low level of prior knowledge performed better under program control when the objective was knowledge acquisition. However, they performed better under learner control when the objective was content review. Students with a high level of prior knowledge performed similarly in both control conditions whether the objective was knowledge acquisition or review. This implies that students with low prior knowledge should begin in an environment with more program control but can be moved to an environment with more learner control as their domain knowledge increases.

Higginbotham-Wheat (1988) suggests that learners should only be given control over context, sequence, and presentation style but should not be allowed to choose instructional events that could alter the amount of content support. If the instructional designer gives up too much control then there is the risk of learners not achieving the desired outcomes. Wydra (1980) sees the designer's role as providing a controlled learning environment in which key decisions are delegated to learners. However, decisions about learning objectives should be made by the designer and the environment structured so that the learners can achieve those objectives.

With all of the inconclusive research on learner control, it is surprising that proponents of hypermedia say that instructional materials designed for that medium will provide great benefits to learners because of the increased amount of control and interactivity that they can be provided with. The research has not yet brought us to that point. Perhaps as more and more students grow up using the Internet their overall comfort level will rise and reach a point where they *expect* to control their learning.

Conclusions: Learner Control

There are few open arguments against learner control; there are only arguments for and against the *degree* of learner control. Chung and Reigeluth (1992) conclude, "Our challenge is NOT whether or not learner control should be used, BUT rather *how* to maximize the learners' ability to use the learner control available and to decide what kinds of learner control to make available" (p. 19). However, given the mixed results of learner control studies, it seems unlikely that researchers will ever be able to state unequivocally, "In general, students given more control perform significantly better than those students given less control." It appears that learner control is not an either/or issue. Williams (1993) states:

> I believe it is time to stop asking the research question, "which is better: learner- or program-controlled CBI?" It seems that enough research has been produced to date to justify the conclusion of "take your pick." Rather, I would like to suggest that future researchers fundamentally alter the question to read, "How can I make learner-controlled CBI effective?" (p. 23).

Perhaps the best conclusion that can be made is that designers should attempt to create the best balance between program control and learner control depending on the content to be taught, the group of learners who will be receiving the instruction, and the environment in which the instruction will take place. "Determining the situations in which each type of control (learner vs. program) works best, as opposed to regarding their uses as "all" or "none" (McCann, 1981), remains an important issue for future instructional technology research" (Ross & Morrison, 1989, p. 29). Based on the results of past research with learner control, three major questions should be addressed by future research:

1. Which specific learner control strategies are the most effective?

2. Which aspects of the hypermedia environment should be controlled by the designer, and which aspects should be controlled by the learners?
3. What is the right type and amount of control to provide for students of varying abilities and characteristics?

To begin with, researchers need to stop looking at the broad variable of learner control and instead look at the narrower variables that contribute to more or less control. "Instead of allowing students to have control over all instructional strategy options, future research should allow students to control only certain options to determine the impact of this type of control" (Klein & Keller, 1990, p. 146). Because there are many different ways of defining the term learner control, it may be best to look at learner control as a continuum comprising many different instructional strategies as opposed to just two polar opposites (program control and learner control). Snow (1980) refers to these two extremes on the continuum as the "Adult Scholar Model" (complete learner control) and the "Child Robot Model" (virtually no control). He states that certain learners may operate best close to these extremes, but for most learners the best level of control is probably somewhere between these two extremes. The fundamental task for researchers is to determine the specific types of control that should be given and in what situations it should be given.

In addition, studies should examine the unique characteristics of hypermedia that allow learners to take more control of their learning. The flexible characteristics of hypermedia provide an excellent environment in which to investigate various learner control strategies. With the increased use of hypermedia in both traditional and distance-based education, these types of investigations are both necessary and required. Marchionini (1988) believes that hypermedia holds much promise for self-directed learning, but designers have to be able to "shape this potential into quality learner control experiences. We want our students to learn to explore information freely and easily, but with purpose and discipline" (p. 9).

Finally, learner control studies need to go beyond the previous research to examine how individual learner characteristics interact with various forms of learner control. Learner characteristics include any trait that might have a discernable effect on the types of instructional strategies chosen. Klein and Keller (1990) identify this as a gap in the learner control literature: "Scholars have not systematically examined the effects of both affective and cognitive learner characteristics on motivation and performance when learners are given control over instruction" (p. 140). Snow (1980) concluded that although learner control has not been conclusively shown to improve the achievement of learners, it is nonetheless important to explore the individual differences that might warrant more learner control for some and less learner control for others. He adds, "One can perhaps give control to all of the learners some of the time, and to some of the learners all of the time. The problem is to determine which learners to give control to when" (p. 158). Friend and Cole (1990) add, "Learner control in CBI is an important aspect that must be seriously considered in instructional design and implementation. The teaching style of CBI and the limits and extent of learner style control must be matched with the learning style of the individual learner" (p. 49). A review of the research seems to indicate that students who possess certain characteristics will perform better in learner-controlled environments, whereas students lacking in certain characteristics will perform better in program-controlled environments. There are encouraging results from studies that have looked at factors such as prior experience, ability level, and motivation.

In closing, future research needs to identify those individuals who are likely to succeed in learner-controlled instruction, as well as those who are unlikely to succeed. Along the way, questions should be raised concerning how to structure instructional experiences so that they equalize the achievements of poorer students without penalizing the better ones. A closer look at individual learner characteristics may hold some of the answers to these questions. Wilcox (1979) reviewed fourteen studies involving learner control and concluded that learner control of certain instructional characteristics can interact with certain learner characteristics. Learner characteristics he mentioned include previous ability, anxiety, and locus of control. In particular, because of its focus on individual control beliefs, locus of control would seem to be a relevant characteristic to consider when designing learner-controlled instruction.

Locus of Control

Locus of control is a personality construct that deals with the expectancy or belief regarding the reinforcements that follow a behavior. Individuals with an internal locus of control orientation believe that reinforcements are a result of personal effort, whereas individuals with an external locus of control orientation believe that reinforcements occur as a result of forces outside of their personal control. This means that internals see themselves as generally in control of their environmental contingencies, while externals see the contingencies as being controlled by fate, luck, chance, or powerful others. In light of the development of technologies that allow learners a greater amount of control over their learning, it may be relevant to once again look at locus of control as an important variable in research studies, particularly those involving learner-controlled and hypermedia-based learning environments.

Overview of Locus of Control

Locus of control had been discussed since the late 1950s. However, it came to prominence as a valid object of research after the publication in 1966 of a monograph entitled

“Generalized Expectancies for Internal Versus External Control of Reinforcement” by Julian B. Rotter. In the article, Rotter set out the foundations of his theory regarding the locus of control construct, provided a wealth of background research to support its validity, and described the development of a test to measure individual differences in a generalized belief in internal-external control.

Rotter’s social learning theory. Locus of control was actually a product of Rotter’s social learning theory, which was introduced in the 1950s. Indeed, his social learning theory provides much of the theoretical background for the locus of control construct. Rotter’s social learning theory was unique at the time in that it attempted to integrate the stimulus-response, or reinforcement, theories on one hand and the cognitive theories on the other hand. According to Rotter, there are four basic concepts that aid in the prediction of behavior: behavior potential, expectancy, reinforcement value, and the psychological situation. Behavior potential is the probability that a particular behavior will occur in a given situation in relation to other alternatives. Expectancy is the perceived probability that a certain behavior will be followed by a particular consequence in a specific situation or situations. Reinforcement value is determined by an individual’s preference for a reinforcement to occur compared to other equally probable consequences. Finally, the psychological situation is the set of internal and external stimuli that are acting upon an individual at a certain time (Rotter, Chance, & Phares, 1972). According to Rotter’s social learning theory, “the general formula for behavior is that the potential for a behavior to occur in any specific psychological situation is a function of the expectancy that the behavior will lead to a particular reinforcement in that situation and the value of that reinforcement” (Rotter, 1975, p. 57). Thus, an individual’s behavior is determined “not only by the nature or importance of goals or reinforcements but also by the person's anticipation or expectancy that these goals will occur" (Rotter, 1954, p. 102).

Rotter identifies two major types of expectancies: specific and general. Specific expectancies develop from specific experiences with particular situations. Generalized expectancies stem from the generalization of specific expectancies to a broader class of similar situations. Thus, expectancies for a given situation are a function of the reinforcement history in related situations and a generalization of expectancies from other related behavior-reinforcement sequences (Rotter, 1954). As experiences build up in particular situations, an individual develops specific expectancies for those situations. These specific expectancies will then contribute more heavily to future behavior in similar situations, and general expectancies will play less of a role. When entering new or novel situations people will base their behavior primarily on generalized expectancies. As time goes on and people obtain additional information about how they will do in a particular situation, the importance of generalized expectancies gives way to specific expectancies based on experience in that situation (Duke & Nowicki, 1979).

The relative importance of specific and generalized expectancies in the same situation is partially determined by the amount of experience in the specific situation. The following formula explains how specific and generalized expectancies affect learning in various situations (Rotter et al., 1972, p. 25):

$$E_{S1} = f\left(E'_{S1} \;\&\; \frac{GE}{N_{S1}} \right)$$

In the formula, *E* represents the expectancy, *S1* represents the specific situation, E' represents the expectancy for a given reinforcement to occur based on previous experiences in the same situation, *GE* represents expectancies generalized from other situations, and *N* represents the amount of previous experience the individual has had in the specific situation. The formula indicates that the importance of the generalized expectancy goes up as the situation is more novel and goes down as the individual's experience in that situation increases.

"In social learning theory, a reinforcement acts to strengthen an *expectancy* that a particular behavior or event will be followed by that reinforcement in the future" (Rotter, 1966, p. 2). Once the expectancy for a behavior-reinforcement sequence has been built up, the lack of the expected reinforcement will reduce the expectancy and thus the resulting behavior. Rotter then hypothesized that when the reinforcement is not perceived to be contingent upon the individual's own behavior, the reinforcement will not increase the expectancy as much as when it is seen as contingent. Thus, the individual's resulting behavior will be affected differently. Based on individuals' differing histories of reinforcement, they will likely differ in the degree to which they attribute reinforcements to their own actions, even within the same situation. These ideas provided the foundation for the locus of control construct.

The locus of control construct. Rotter was interested in a variable that might help refine the prediction of how reinforcements change expectancies (Rotter, 1975). Rotter believed that the differences in how people attribute situational control would be consistent, and thus this variable could be important in understanding the nature of learning processes. This could in turn lead to important ramifications for the design of instructional environments that correspond to individual learning differences. Rotter and his colleagues carried out a series of studies designed to explore this potential variable, most of them based on various skill and chance comparisons. He also cites a variety of earlier research. For example, in a 1959 article (as cited in Rotter, 1966), Feather concluded that motivation was lessened in tasks that required chance compared to those that required skill. In a 1946 article (as cited in Rotter, 1966), Merton stated that a belief in luck or chance was often used by individuals to feel better about themselves in the face of failure. Rotter even goes back to 1899 to cite Veblen (as cited in Rotter, 1966), who felt that a belief that luck or chance controlled one's actions resulted in less productivity and a general passivity.

These studies provided evidence that people differ in their reactions to success and failure, and these differences in turn affect future performances. After examining all of the results, Rotter (1966) reached the following conclusions:

> People in American culture have developed generalized expectancies in learning situations in regard to whether or not reinforcement, reward, or success in these situations is dependent upon their own behavior or is controlled by external forces, particularly luck, chance, or experimenter control, which are fairly consistent from individual to individual. If subjects perceive a situation as one in which luck or chance or experimenter control determines the reinforcements, then they are less likely to raise expectancies for future reinforcement as high following success, as if they perceived the reinforcement to be dependent upon skill or their own efforts. Similarly, they are less likely to lower expectancies as much after failure. They are less likely to generalize expectancies of success and failure or expectancies of future reinforcement as much from one task to another similar task… Finally, under conditions where they perceive the task as luck, chance, or experimenter controlled they are more likely to raise expectancies after a failure or to lower them after a success. (p. 25)

These conclusions led Rotter to hypothesize a construct to help explain human behavior. "One main interpretation of these studies is that research in human learning should be understood or interpreted in light of the position on a continuum of internal to external control that the task and procedure will be perceived by the subjects" (p. 25). The construct was termed *locus of control*, and was explained as follows:

> When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then in our culture it is typically perceived as the result of luck, chance, fate, as under the control of powerful others, or as unexplainable because of the great complexity of the forces surrounding him. When the event is interpreted this way by an individual, we have labeled this a belief in *external control.* If the person perceives that the event is contingent upon his own behavior or his own relatively permanent characteristics, we have termed this a belief in *internal control.* (p. 1).

Thus, with the locus of control construct, if an individual develops the expectancy that behavior A will result in event B, and if event B is valued, the probability that A will be performed is higher. If enough of these results occur then a generalized expectancy will develop regarding an individual's behavior and the resulting consequences. As individuals encounter novel situations, they rely on the generalized expectancies that have worked well in the past. Locus of control is considered a *generalized expectancy* because it operates across a large number of situations, and is based upon previous experiences.

Rotter believes that it is important to realize that if a person perceives a reinforcement as contingent upon his own behavior, then the occurrence of either a positive or negative reinforcement will strengthen or weaken the potential for that behavior to recur in the same or similar situation. If the reinforcement is perceived as being outside of an individual's control or dependent on chance, fate, or powerful others, then the preceding behavior is less likely to be strengthened. As an example, he describes a situation in which an individual looking for an unusual brand of tobacco finally finds it at a particular store. Because the person's actions directly led to the positive reinforcement, that person is more likely to return to that same store in the future. In contrast, a person who needs money and finds a five-dollar bill on the sidewalk is not as likely to return to that spot when again needing money because the reinforcement would be more likely attributed to chance (Rotter, 1966).

Cognitive perspective. The locus of control construct stems from a behaviorist perspective in that it deals with reinforcement of stimulus, but it adds a cognitive aspect to the typical behaviorist philosophy in that the reaction to the reinforcement depends on the individual's cognitive viewpoint as to where control of this reinforcement lies. In other words, it is dependent on how much an individual believes the rewards they receive are a consequence of their own behavior or external forces. "The effect of a reinforcement following some behavior on the part of a human subject, in other words, is not a simple stamping-in process but depends upon whether or not the person perceives a causal relationship between his own behavior and the reward" (Rotter, 1966, p. 1). Lefcourt (1982) further explains the concept:

> It is not the simple registering of success and failure experiences that is pertinent to the generalized expectancy of internal versus external control, but rather it is the interpretation of the cause of those experiences. It differs from the expectancy of success or failure in that it is concerned with our beliefs about how reinforcements are determined and should, therefore, provide an independent contribution along with freedom of movement and need value to the prediction of goal-directed activity. (p. 34)

During the 1960s, cognitive psychology was emerging, and the locus of control construct was a way to connect behaviorist theories with cognitive theories (Rotter, 1975). Before that time, much of personality psychology had been concerned with figuring out which needs or drives were the sources of behavior. As interest in cognitive psychology emerged, researchers became more interested in cognitive explanations of behavior, which involved conscious purpose and choice. Constructs such as locus of control allowed researchers to take a new look at problem behaviors that had previously been attributed to faulty motivation (Lefcourt, 1992). It also helps explain how certain cognitions about control influence behavior change (Marks, 1998).

Locus of control scale. Rotter developed a scale to measure an individual's internal-external orientation. The scale is referred to as the I-E scale and provides a measure of individual differences in a generalized belief for internal versus external control of reinforcement. It consists of 29 forced-choice items. Of the 29 items, 23 relate to internal-external expectancies, and 6 are filler items intended to disguise the purpose of the test. Construct validity was determined after many studies predicted differences in behavior for individuals above or below the median of the scale. In addition, item and factor analyses indicated high internal consistency, test-retest reliability was satisfactory, and the test correlated satisfactorily with other methods of assessing the same variable. Discriminant validity was indicated by low relationships with other variables, such as intelligence, social desirability, and political liberalness (Rotter, 1966).

Multiple factors and scales. Rotter (1966) originally hypothesized that the locus of control construct was multidimensional. Rotter, Seeman, and Liverant (1962) had originally suggested separating externals into four dimensions: belief that events occur due to luck or chance, belief that events occur due to fate, belief that events are controlled by powerful others, and belief that the world is too complex to be predicted. The theory was that beliefs in control by powerful others would lead to different thoughts and actions than beliefs in control by fate or chance. Powerful others may be a result of certain political or cultural differences between populations. However, early attempts at factor analysis led to the conclusion that a single general factor accounted for the variance; there were no clear-cut subscales identified. Therefore, it was operationalized as a unidimensional, bipolar construct.

The original Rotter I-E scale was developed to measure a generalized expectancy of reinforcement over a wide range of situations and is therefore bound to have relatively low predictive validity in specific situations (Rotter, 1975). However, some researchers have sought to increase its predictability in different areas by isolating different locus of control factors. Most subsequent attempts to break down the locus of control scale into separate factors have not generally resulted in a significant increase in its predictive behavior. However, Levenson (1981) developed a three dimensional locus of control scale. In addition to internal control (I), she separated external locus of control beliefs into two dimensions: control by powerful others (P) and control by chance or fate (C). These came to be known as Levenson's I-C-P scales. In addition to Levenson's scales, there have been many other specialized scales developed to test different domains or groups of people. Lefcourt (1982; 1981; 1983) identifies over a dozen separate scales. The following are some of the more common or notable scales:

1. Rotter I-E Scale. Rotter's original locus of control scale.
2. James-Phares Scale. An early scale developed in 1957.
3. Bialer Scale. An orally administered scale for children developed in 1961.
4. Crandall Intellectual Achievement Responsibility Questionnaire (IAR). A scale designed to measure locus of control in the academic environment.
5. Children's Nowicki-Strickland Locus of Control Scale (CNSIE). Similar to Rotter's scale, but developed specifically for children.
6. Adult Nowicki-Strickland Locus of Control Scale (ANSIE). Similar to Rotter's scale, but developed specifically for adults of any education level.

7. Levenson’s I-C-P Scales. Described above.
8. Multidimensional-Multiattributional Causality Scale (MMCS). Assesses achievement and affiliation.

Rotter (1975) encourages the examination of subscales within the I-E scale, as well as the development of new scales. He cautions, however, that a factor analysis of a scale may not reveal the true nature of the concept, particularly a scale designed to give results over a broad range of behaviors or situations. Subscales may be useful only if “they demonstrate that reliable and logical prediction can be made from the subscale to specific behaviors and that a particular subscale score produces a *significantly higher relationship than that of the score on the total test*” (p. 63).

Summary. Locus of control is concerned with the question of whether or not an individual believes that his own behavior, skills, or internal dispositions determine what reinforcements he receives. It is *not* concerned with whether the individual is controlled from within or from without, such as by individual goals and desires or social forces. This is an important distinction, as individuals on one scale may not line up in the same place on the other scale. In a more recent article, Rotter (1990) revisited the locus of control construct and provided the following concise definition:

> Briefly, internal versus external control refers to the degree to which persons expect that a reinforcement or an outcome of their behavior is contingent on their own behavior or personal characteristics versus the degree to which persons expect the reinforcement is a function of chance, luck or fate, is under the control of powerful others, or is simply unpredictable (p. 489).

Those with an internal locus of control are more likely to change their behavior following a positive or negative reinforcement than those with an external locus of control. This is because internals believe they have control over the reinforcements, whereas external believe that changing the behavior would not have an effect on the reinforcements. Externals may additionally have increased feelings of helplessness and frustration, since they feel that they do not have control over situations in their life. An internal locus of control is therefore generally considered preferable.

Why is this important for instructional designers and educators? Imagine a classroom full of students who are all external. The instructional methods required to effectively teach to these students would undoubtedly be very different from the strategies used to teach to a class full of internal students. Therefore, knowing the makeup of a group of learners can help educators and instructional designers develop instructional materials that are better tailored to the needs and characteristics of their group of learners. This makes it an important variable to consider in educational research. Many studies have explored the predictive ability of the locus of control construct with regard to academic achievement in the hope of prescribing effective instructional strategies for learners of differing locus of control orientations. The following sections will summarize the research in this area.

Locus of Control and Academic Achievement

Because externals do not perceive the contingencies between their behavior and outcomes, it would seem that externality would reduce the amount of learning that takes place, particularly in novel situations, for which learners have no specific expectancies. Many students believe that no matter how hard they try they will fail for reasons beyond their control. They do not see the relationship between their efforts to succeed and the grades they receive and thus refuse to take responsibility for their grades, instead believing that teachers “give” grades. As a result, they do little to help themselves academically and fail to learn course content. Numerous studies have been carried out using locus of control in a variety of subject areas and with students from a variety of grade levels. A more complete summary of studies on locus of control and academic achievement can be seen in Appendix B.

Locus of control in different grade levels. One of the earliest (and largest) studies (Coleman et al., 1966) found that locus of control was strongly related to the academic achievement of high school students, particularly regarding minority students. In fact, locus of control was a better predictor of achievement than any of the other variables that were studied. The researchers concluded that the educational system must do all it can to promote a strong sense of “self” in children in order to help them achieve their full potential. Another early study (Bartel, 1971) found that children with an internal locus of control had greater achievement than children with an external locus of control, particularly as they progressed to higher grade levels. Many other locus of control studies have been carried out with younger students. Young and Shorr (1986) looked at a large sample of fourth, fifth, and seventh graders and found a positive correlation between locus of control and academic achievement, even when all the other variables in the study were taken into account. Nunn, Montgomery, and Nunn (1986) looked at 268 students in grades five through eight and found significant correlations between internal locus of control and achievement in mathematics and language, as well as on the Iowa Test of Basic Skills. Perna, Dunlap, and Dillard (1983) found a positive relationship between internal locus of control orientation and the achievement of emotionally disturbed boys aged 10 to 15.

A study by Daniel, LaBert, and Haydel (1993) looked at health locus of control to see if it correlated with achievement in a variety of areas. The health locus of control scale determines whether students view themselves, others, or chance as primarily responsible for their overall health. Results indicated a positive correlation between health locus of control and the academic achievement of seventh graders, suggesting that students' health attitudes can have an effect on their academic performance.

Locus of control has also been examined using children in other countries. Galejs and D'Silva (1981) found that Nigerian children with an internal orientation performed significantly better in language and mathematics than children with an external orientation. Two studies by Maqsud (1983; 1993) also used Nigerian children and found that internals had significantly higher achievement and self-concept than externals. Similarly, Rupp and Nowicki (1978) found a positive relationship between internal locus of control and achievement in Hungarian children. They used the Nowicki-Strickland Internal-External control scale and suggest that the results obtained using this scale are comparable across cultures. Another study (Bar-Tal, Kfir, Bar-Zohar, & Chen, 1980), this one conducted using 2,438 ninth-grade Israeli students, found that internals tended to attain greater academic achievement than externals, even when controlling for the effects of socio-economic status.

Studies using college students have also reported increased achievement for internally oriented learners. Duke and Nowicki (1979) reported that an internal locus of control in male college juniors is positively related to achievement. Wuenach and Lao (1975) reported significantly higher achievement for internal college students compared to external college students, as well as an interaction between internality and need for achievement. They indicate that among students with a high need for achievement, only the internal ones actually achieve better. Separate studies by Pigge and Marso found that internally oriented student teachers performed better (1989) and were less anxious about teaching (1994). In addition, it has been shown that internal teachers are rated as more effective by their supervisors than external teachers (Soh, 1988).

Locus of control in different subject areas. Experimental studies using locus of control have been conducted in almost all subject areas. Brooks and Hounshell (1975) found that elementary students with an internal orientation scored significantly higher on science achievement tests than those with an external orientation. Saunders-Harris and Yeany (1981) found that internally oriented middle-school science students performed significantly better on a delayed retention test than externally oriented students. De Santi and Alexander (1986) reported that internals had a significantly higher reading achievement level than externals, as well as a better attitude toward reading. On the negative side, Edwards and Waters (1981) found no relationship between college students' locus of control and their scores on the verbal portion of a college qualification test, while Mintzes (1979) found no significant differences between internal and external college students in biology achievement.

Culver and Morgan (1977) concluded that college students' scores on Rotter's I-E scale did not correlate with reading achievement. However, their study also used Levenson's I-P-C Scales and did find some significant results. As described earlier, Levenson (1981) developed her locus of control scales to differentiate between those externals who believe reinforcements are controlled by chance and those who believe reinforcements are controlled by powerful others. In this study, there was a significant positive correlation between the internal scale and reading achievement and a significant negative correlation between the external chance scale and reading achievement. Drummond, Smith, and Pinette (1975) also looked at locus of control and reading achievement, this time using community college students. The results indicated that the externally oriented students performed significantly better on a reading achievement posttest.

They suggested that the internal students might have felt more confined by the learning environment, which, while individualized, was very structured.

Large-scale studies. Many large-scale studies have been conducted using locus of control as a variable. Analysis of data from a national longitudinal study of 22,660 high school seniors indicated that locus of control has a significant impact on achievement, with internals achieving at a higher level even after other variables are controlled for (Keith, Pottebaum, & Eberhart, 1985). Sterbin and Rakow (1996) analyzed the data from a national longitudinal study involving over 12,000 high school students. The results indicated that students with a higher internal locus of control achieved higher scores on standardized tests. In yet another longitudinal study, Croucher and Reid (1979) looked at the locus of control orientation of 1000 nine and ten year olds and found that an internal orientation was positively related to academic achievement. Finally, a study involving 944 fourth and fifth-grade students also found that internals had significantly higher achievement scores than externals (Tesiny, Lefkowitz, & Gordon, 1980). In addition, externality was associated with higher levels of depression.

Summary. In reviewing the research on locus of control and academic achievement, Lefcourt (1992) concluded that the majority of studies indicated a positive relationship between internal locus of control and academic achievement. However, not all of the research has shown this to be the case. Prociuk and Breen (1973) found no relationship between locus of control and academic achievement. Similar results were reported by Darwazah (1998) regarding a study involving 500 students. In a study involving 184 college students, Wilhite (1990) concluded that the students with an external locus of control performed better than the students with an internal locus of control. This was a correlational study, however, so there were no treatment groups to compare. Lefcourt (1982) notes that such findings point to a need for well designed experimental studies that seek to find out how the characteristics of the learning environment may mediate the relationship between locus of control and achievement. Nowicki (1982) concurs: “The type of situation probably plays some significant mediational role between people’s expectancies and their resultant behavior. Such is the case with the locus of control and achievement relation” (p. 158).

Locus of Control Interactions

Wright and DuCette (1976) noted that in much of the research on academic correlates of locus of control,

> too little attention is paid to the academic setting in which the research is performed, and what demands and rewards are in these settings. The question in most of these studies has been: “Does locus of control predict achievement?” The question might better have been: “Does locus of control predict achievement in this setting, with this teacher, and with these pupils?” As such, the question is posed in Aptitude X Treatment interaction terms. This type of research, as Cronbach (1975) points out, is a far more meaningful way of posing educational questions. It would seem to be a better way of posing locus of control questions also. (pp. 4-5)

The authors suggest that internal students will achieve better if, and only if, the instructional environment allows a contingent relationship to exist between effort and reward. Lefcourt (1982) adds:

> In recent years there has been a growing trend toward the use of interactionist models. Instead of asking whether internals are more apt to perform competently on achievement tasks than externals, questions have been refined somewhat so that investigators are

> beginning to ask when and under what conditions locus of control is likely to afford valuable predictions. (p. 89)

The interest in how individual differences (such as locus of control) interact with instructional conditions led to the Aptitude-Treatment-Interaction (ATI) model of research, which looks at the relationship between individual learner characteristics and the characteristics of the instructional environment. This model assumes that *there is no single instructional approach that is best for all learners*. Individual learner characteristics will largely determine what approaches will work best in any given situation. The assumption is that individual differences in learner characteristics (aptitudes) “interact” with instructional methods (treatments) to produce differential outcomes (Cronbach & Snow, 1981). Thus, ATI research is interested not only in how a single variable affects learning outcomes but also if any results with that variable are dependent on its interaction with another variable. In many cases, a single variable does not have an effect on a dependent measure but instead comes into play only when combined with another variable. Results of ATI studies have practical implications for the use of certain instructional methods in the course of teaching:

> This research seeks to establish relations between learner characteristics and instructional treatments that will permit instructional designers to specify that one mode of instruction is ideal for a group of learners with one set of characteristics while an alternate method is optimal for a group of learners with different characteristics. (Driscoll, 1987, p. 3)

Prescriptions derived from ATI studies can be used to develop instruction for a group of learners that accommodates the aptitudes they have or compensates for the aptitudes they lack. With that goal in mind, many studies have looked at the interaction between locus of control and various instructional strategies.

Instructional methods. Fisher and Dyer (1978) investigated locus of control and the use of either hardware- or software-based reading improvement tools. The hardware tools included reading pacers and listening tapes, while the software tools included workbooks, skills exercises, and texts for reading improvement. The hardware options were considered “external” devices, while the software options were considered “internal” devices because they involved internal self-improvement skills. The results of the study indicated that freshman students with an external locus of control who used the hardware devices performed significantly better on a posttest than externals using the software devices. In addition, internals using the software devices performed significantly better than internals using the hardware devices.

A study by Yeany, Helseth, and Barstow (1980) examined the relationship between locus of control, interactive instructional video tapes, and the science achievement of college students. It was expected that the increased freedom allowed by the use of the interactive videos would lead to better achievement by the internally oriented students. The results indicated that locus of control was not a predictor of achievement. The authors suggest that college students may overcome their external tendencies or that externally oriented students may be less likely to end up in college.

Wesley, Krockover, and Hicks (1985) also looked for an interaction between locus of control and instructional method. Both of their treatments contained the same information; the only difference was that one set of materials was printed and one was presented on a computer. Their dependent variable was achievement on a computer literacy assessment. Using preservice elementary teachers as subjects, they found no main effects for locus of control. This probably resulted from their two treatments being too similar. However, they did report an interaction between locus of control and the cognitive subscale of their assessment instrument, indicating that externals who interacted with the computer version performed better on that subscale than those with the paper version.

McLeod and Adams (1980) conducted three studies that examined various ways of organizing instructional materials. Their treatments differed in the methods used to encourage discovery learning in mathematics. In the first experiment, the level of guidance given to learners was varied, with one group receiving more teacher guidance than the other. Results indicated that students in the high-guidance group performed significantly better on both a posttest and a retention test. There were no effects for locus of control. In the second experiment, inductive and deductive reasoning strategies were compared. Students in the deductive group performed significantly better on the posttest but not the retention test. Once again, there were no effects for locus of control. Finally, in the third experiment, students worked individually or in groups. Results here indicated a disordinal interaction on the retention test, with internals in the small-group treatment performing better and externals in the individual group treatment performing better. Since the students working individually received more teacher guidance, it was suggested that external students perform better when they have access to teacher assistance. It is not certain why the third experiment produced the only significant effects for locus of control, but closer inspection reveals that the treatments in that experiment were the most varied in terms of instructional differences. In addition, the sample size was much higher in the third experiment.

Nowicki (1982) investigated how competition, cooperation, and locus of control affects children’s achievement. There was a significant interaction between locus of control and treatment condition. Internals who competed against themselves or against another student performed significantly better than externals in the same situation. However, when students had to cooperate with another student, internals and externals performed the same; externals actually increased their performance to match that of internals and did significantly better than externals in the non-cooperative situations. These results raise interesting questions about possible situational factors that can improve the performance of externally oriented individuals.

Miscellaneous instructional strategies. Moore and Dwyer (1997) examined the interaction between locus of control and the color-coding of visuals. Students in one group received printed materials containing illustrations that were color-coded according to the various concepts being presented. Students in the other group received the same materials except that the illustrations were in black and white. It was hoped that the color-coding of concepts and processes would provide externals with a greater understanding of the information presented in the instructional environment. While there were significant achievement differences related to the color-coding, there were no significant differences related to locus of control. The authors suggest that their sample of college students may have been naturally internal and resistant to the dichotomy created by the I-E scale or that students were not aware that the illustrations were color-coded by concept.

Cohen (1982) found that external fifth-grade science students who were given access to manipulatives performed significantly better than external students who were not given access to manipulatives. This suggests that the use of manipulatives in science study can be a beneficial strategy for external students. There was no difference between internal students, which supports the theory that internals will do well in a variety of situations.

Segal (1974) used advance organizers in an attempt to accommodate students with an external locus of control. The justification for using advance organizers is that the learning of new material can be facilitated by anchoring the new material within individuals' current cognitive structure. If this connection is not available or not recognized by the learner, then suitable organizers can be provided within the instruction in advance of the new learning material to ensure that new anchoring ideas will be available (Ausubel, 1968). The results of Segal's study indicated that the advance organizers had a significant facilitating effect on students with a low socioeconomic status and an external locus of control.

In a similar study, Sherris and Kahle (1984) found a significant interaction between locus of control and concept-related instructional organization. The concept-related treatment included various advance organizer strategies, such as statements explaining the importance of the concepts and principles. Results showed that external students in the concept-related treatment group performed significantly better on a retention test than external students in the control group, while internal students performed the same regardless of the treatment. As in the previous study, these results indicate that various instructional strategies may be effective at increasing the performance of externally oriented learners, perhaps even bringing them up to the performance level of internally oriented learners.

Another interesting study (Collins-Eiland, Dansereau, Brooks, & Holley, 1986) found a significant interaction between locus of control and conversational noise. Internally oriented college students exposed to noise during an instructional task performed better on a posttest than externals who were exposed to the same noise. The authors suggest that this is because externals give up easier under stressful conditions, while internals rise to the challenge and attempt to control the situation. Research has shown that individuals with an internal locus of control are better able to withstand stressful events (Lefcourt, 1976). Lefcourt believes that this is because internals feel that they are better able to control the events in their life.

Computer interactions. Several studies utilized instructional strategies involving the provision of advisement, feedback, or guidance from a computer-based instructional lesson. Van

Damme and Masui (1980) looked at locus of control and its possible interaction with three instructional methods. One method was a traditional lecture, and the other two were variations of a personalized system of instruction that differed in the amount of guidance given. Results indicated that the external students performed better when given more guidance. Another study (Wilhite, 1986) found a relationship between internal locus of control and the use of adjunct questions. Internal students who were presented with embedded adjunct questions when reading a passage performed significantly better on a multiple-choice test on reading comprehension than internal students who were not presented with the adjunct questions. There was no significant effect for the external students.

Yeany, Dost, and Matthews (1980) used a diagnostic-prescriptive instructional method in which diagnostic tests were given, feedback provided, and optional remedial activities assigned. It was expected that internal college students would perform better with the diagnostic-prescriptive treatment since internals are more open to information that may influence their success. However, the results indicated that there was no interaction between locus of control and the instructional method. The authors suggest that the Rotter scale may not be an accurate measurement of the locus of control of college students. However, it may be that while internals are generally more apt to take control of their learning, they may not do so if they perceive remedial activities to be controlled by others (Rotter, 1966). If this is the case, perhaps they would be more receptive to remedial activities if they were suggested by the computer, as this could be seen as less personal.

Locus of control can also affect achievement based on the type of test given. One study (Wise, Roos, & Plake, 1994) found a disordinal interaction between locus of control and test type. Students were given either a self-adapted test, which allowed them to choose the difficulty of the questions, or a computerized adaptive test, in which the computer determined the difficulty of the questions based on previous responses. Students with an internal locus of control performed better with a self-adapted test, while externals were negatively affected by the self-adapted test. Nishikawa (1988) looked at the interaction between locus of control and feedback strategy in computer assisted instruction. The results indicated that internals performed significantly better than externals under the delayed feedback conditions. These results support the theory that externals prefer not to delay gratification or rewards.

Locus of Control and Learner Control

Because internals feel they have more influence over their environment, they are more likely to seek ways to control the learning environment, particularly if that control can be influential in attaining their goals. Because of this, there may be links between locus of control and learner control, particularly in computer-based learning environments. Internals may prefer and make better use of control options, while externals may prefer situations in which they do not have to be in control. Relatively few studies have been conducted that have specifically combined locus of control and learner control, and fewer still have looked at those variables in a hypermedia or computer-based environment.

Implicit learner control. Several studies have looked at locus of control and different methods of structuring learning environments in ways that provide learners with more choices. While these various learning environments may not be explicitly referred to as “learner control,” and while many of them are not computer-based, there is no doubt that many of them differ in the amount of control they afford to the learners. Reviewing these studies can help explain the effect that locus of control has on learners in different instructional environments.

An early study by Allen, Giat, and Cherney (1974) was conducted using a personalized instruction course. A personalized instruction course is one that affords more control over the rate at which students work through the instructional materials. Results of their study indicated that although internals and externals both had similar GPAs prior to the course, the externals ended up with significantly lower final scores in the course. Their conclusion was that internals maintain a constant level of performance regardless of the format of the course, while externals do much poorer in courses that stress student control of contingencies. Results such as these imply that while traditional forms of instruction may work well for all learners, instruction that affords learners more control works inherently well only for those with an internal locus of control. The authors suggest that instructional methods should be tailored to the characteristics of the individuals because not all forms of teaching are equally effective for all learners.

Two other studies that examined locus of control and performance in a personalized system of instruction (PSI) found that locus of control had no effect on achievement (Johnson & Croft, 1975; Keller, Goldman, & Sutterer, 1978). All of these studies used intact classrooms as opposed to experimentally controlled groups, so it is difficult to draw any generalizations from them. In addition, it is important to keep in mind that there are many factors at work in a PSI. It appears that each of these studies used different strategies within their classes. Because of this, a PSI cannot be considered a single independent variable. Even so, studies by Jonassen (1985) and Grabinger and Jonassen (1988) have indicated that when given a choice between a traditional, teacher-centered course or a PSI course, students who chose the PSI course had a significantly higher internal locus of control. This suggests that internals are attracted to the open environment provided by these types of courses.

Daniels and Stevens (1976) found a disordinal interaction between locus of control and two methods of instruction. They used 146 college students as subjects. Students in one treatment group were given a traditional, teacher-controlled method of instruction. They were required to attend all lectures and take all weekly tests. Students in the other treatment group were involved in a contract for grade plan. The contract for grade plan allowed the students some measure of control over the projects they worked on in the course. Class attendance and weekly test taking was optional. In addition, students were given the chance to complete additional work to bring up sub-par test or project scores. Thus, students had more control over their final grades. Students with an internal locus of control performed significantly better in the contract for grade plan, while the students with an external locus of control performed better under the teacher controlled method. There were no significant main effects reported. While this study looked at two methods of instruction, the two methods employed could be considered to vary in terms of the amount of learner control afforded the learners. Allen and Harshbarger (1977) found similar results with students in a reading improvement course. Internal students in the contract group performed significantly better than internal students in the teacher-controlled group.

McMillan (1980) replicated the Daniels and Stevens study using elementary students. Once again, students were assigned to either a structured learning group or contract-based learning group. The results of this study showed no significant main effects or interaction. The differences might be partially explained by the fact that there was a small sample size and that the treatment period was much shorter than in the earlier study (two weeks as opposed to eight weeks). Still another study similar in nature to Daniels and Stevens' was carried out by Root and Gall (1981). They looked at locus of control and auto-tutorial instruction. Similar to the contract-for-grade plan in the earlier studies, auto-tutorial involves independent study, self-pacing, and the use of audio and video components. The results revealed no effects related to locus of control. The authors suggest that this might be because their study did not have reward contingencies associated with the suggested course deadlines, an element Rotter believes to be important to the locus of control construct (1975).

Several other studies have used similar types of open classroom environments. Wright and DuCette (1976) conducted two studies that compared traditional and open classrooms. In open classrooms, the instruction is flexible, and students are encouraged to take a more active role in their own learning. In addition, the teachers in open classrooms are less authoritarian in their interpersonal behaviors. In the first study, involving 100 students from traditional and open elementary schools, there was a positive relationship between internal locus of control and achievement for students in the open setting, lending further support to the idea that internals perform better in more open settings. There were no significant results for students in the traditional classroom; internals and externals performed similarly. In the second study, involving 177 community college students from traditional and alternative course sections, the results were similar.

Parent, Forward, Canter, and Mohling (1975) concluded that externals performed better under a high-discipline classroom condition, while internals performed better under a low-discipline classroom condition. In the high discipline classroom the teacher dictated class rules and lectured. In the low discipline treatment, students were given instructional books and told to study on their own. In addition, the teacher was available to provide guidance. While these conditions may not be considered varying levels of learner control, it could be argued that a low discipline classroom allows students more control over their environment. It is particularly interesting to note that no main effects were obtained for any of the independent measures, only the interaction effect. The authors concluded that optimal student performance would be obtained when there is a complementary fit between students' locus of control and the external conditions of discipline in the learning setting.

Finally, Horak and Slobodzian (1980) examined locus of control and two methods of structuring science instruction. Seventy-four preservice teachers with varying locus of control orientations were assigned to either a structured or unstructured classroom. The unstructured class consisted of a variety of loosely organized tasks that allowed students to function in a relatively independent manner. Two achievement measures were used: one to measure knowledge of science processes and the other to measure knowledge of science content. For the science process test, students in the structured condition performed significantly better than students in the other groups. For the science content test, there was a disordinal interaction: Internal students in the unstructured class performed significantly better than internals in the structured class, while external students in the structured class performed better than externals in the unstructured class. The authors suggest more similar research be conducted to determine what factors may have contributed to the discrepancy between the results on the two criterion measures.

Explicit learner control. As stated earlier, few studies have explicitly examined the interaction of locus of control and learner control. An early study by Holloway (1978) looked at locus of control and two methods of (non-computer) instruction. In one method, learners were allowed to vary the sequence in which they accessed the instructional content and the times at which they took self-tests. The other group followed a more prescribed arrangement. The results revealed an ordinal interaction between locus of control and the instructional method, which meant that the internal learners performed better when they were given more control. Holloway concluded that internally oriented learners were better at assuming responsibility for their learning when they were given the chance.

Carrier, Davidson, and Williams (1985) examined locus of control and three computer-based treatment groups. In the options treatment, students could choose instructional elaborations as they progressed through the material. In the lean treatment, students saw only the core lesson and could not choose additional material. Finally, in the full treatment, students saw all of the instructional materials but had no choices. Sixty-five sixth-grade students were used as participants. The results indicated a significant main effect for locus of control scores (although the authors do not state what the effect is). In addition, there was a significant interaction between locus of control and treatment group on a delayed posttest. Internal students performed significantly better in the full group than internal students in the option or lean groups. The authors concluded that internals were better able to take advantage of the additional material in the full environment.

Lopez and Harper (1989) also investigated the interaction between locus of control and three levels of learner control. The three levels were classified as no control, moderate control, and high control. In the no-control version, students completed all screens of a computer program, including all practice items and review screens. In the moderate-control version, students were presented with the same information and practice items but had the option to bypass the content review screens. In the high-control version, students could bypass the practice questions and the content review screens for questions they answered incorrectly. Using seventh- and eighth-grade students as participants, the results revealed no significant differences between the learner control groups on an achievement test and no significant interaction between locus of control and learner control. The authors suggest that since students in the high control condition elected to receive almost the same number of practice questions as students in the other groups received automatically, the treatments ended up being very similar. Therefore, achievement differences could not be expected. In addition, all of the treatments were essentially linear in nature, and only differed on the choice of practice questions and review screens.

Klein and Keller (1990) examined locus of control and two forms of computer-based instructional control: learner control and program control. Students in the learner control group were given choices as to additional content, additional practice exercises, and additional feedback. Students in the program control group received all the information in a fixed sequence. The results indicated that students with an internal locus of control performed better on a posttest of achievement. There was no effect for the various learner control treatments and no interaction effect. The authors suggest that their treatments may have been too similar in the degree of learner control and that the amount of control given to the learners may not have been enough to give them the perception that they had control. They add that the lack of effect for learner control can help delimit the degree to which specific aspects of learner control can be isolated and expected to be influential. “Future learner control studies should continue to investigate the impact of individual differences and type of instructional control on motivational outcomes” (p. 146).

Santiago and Okey (1992) looked at locus of control and different methods of advisement in a learner-controlled, computer-based learning environment. In addition to finding significant effects for adaptive advisement, they also found that those with an internal locus of control performed significantly better than those with an external locus of control. Furthermore, both internals and externals followed the advisement given to them with the same frequency and when given a choice completed the same number of practice exercises. There were no interaction effects between advisement and locus of control. It is important to keep in mind that this study did not look at different levels of learner control, only at different methods of advisement within a single level of control.

A study by Gray (1989) looked at locus of control and learner control over branching in a computer-based sociology lesson that involved making policy decisions. There were two branching conditions. In the first condition (review only), students could either branch back to review and/or revise a previous decision or move on to the next topic, but they could not otherwise control the sequence of the instruction. In the second condition (total branching), students could access any decision in any order. The dependent variables were scores on a retrieval task and scores on a retention test. The results indicated that on the retrieval task, internal students performed significantly better than external students. There were no significant effects related to the branching conditions. On the retention test, there were no significant locus of control effects; internals and externals performed the same. However, students in the review-only (low-control) group performed significantly better than students in the total branching (high-control) group.

Coldevin, Tovar, and Brauer (1993) sought to determine the effects of locus of control and learner control on students using interactive video materials. The learner control options they presented differed mainly in the sequence available to the learners. Their results indicated that students given the least amount of control performed the best and that there was no influence from locus of control. It should be noted that they used locus of control as a covariate and not as a true independent variable. In addition, they had a low number of subjects (46) for use in a 3 x 2 factorial design. They suggest that additional research is needed using the locus of control variable due to the limited number of studies in this area. Binette (1992) also looked at locus of control and learner control using interactive videodisc instruction. Seventh-grade science students were assigned to either program control or learner control treatments. Results indicated that there was no difference in treatments and no difference attributable to locus of control tendency. However, in this study, as in many previous learner control studies, the treatments were very similar. The author suggests that a greater distinction must be made between instructional treatments to effectively evaluate interaction between locus of control and treatment groups.

Packard, Holmes, Viveiros, and Fortune (1997) looked at locus of control in a hypermedia environment in which the presentation mode was varied. Students were assigned to one of three modes: text-only, text with static graphics, and text with animated graphics. The results revealed no differences attributable to locus of control. While this study did not involve different levels of learner control, the authors suggest that if students are allowed more freedom of choice in how they access information in a hypermedia system, the differences between internals and externals may play a greater role. In another hypermedia study, MacGregor (1999) found that externally oriented seventh and eleventh graders exposed to a hypermedia environment tended to use the existing navigation structure, while the internally oriented students were able to purposely structure their navigation and make more non-sequential connections. Care must be taken in interpreting these results, however, due to the limited number of participants.

It appears that many of the same problems identified earlier as plaguing learner control research also affect many of the studies that examine both learner control and locus of control. These include problems with operationalizing learner control and the often-minute differences between treatment groups. For example, it is interesting to note that in one study, the treatment group that provided students with all of the instructional material but no control was referred to as the “full” group, while in another study the treatment group with the same instructional condition was referred to as the “no-control” group.

Problems with Locus of Control Research

There are not as many problems with the locus of control research as there are with the hypermedia and learner control research. However, some problems have been identified. Rotter revisited the locus of control construct in a 1975 article and identified several problems with the research he examined. According to Rotter, the most frequent conceptual problem is the failure to treat reinforcement value as a separate variable. Rotter suggests that the value of the reinforcement is very important to the locus of control construct. To make a locus of control prediction one must either control reinforcement value, or measure it and systematically consider it (Rotter, 1975). This problem is particularly important in research involving social action, social protest, independence, conformity, and other related areas.

There is also some concern with the number of locus of control scales that have been developed. There are over 50 separate scales that claim to measure the locus of control construct (Carton & Nowicki, 1994). Many of these scales are domain specific and employ narrowly defined control expectancies in the hopes of increasing the prediction of specific behaviors. A more specific measure of generalized expectancy will allow greater prediction for situations that are similar but poorer prediction for other situations that are not as similar. Carton and Nowicki suggest that these scales may not all be appropriate measures of what Rotter defined as a “generalized” expectancy that cuts across many different areas. Rotter freely acknowledges that generalized expectancies “have their limitations, since they represent only one of many variables that enter into the prediction of behavior, and their relative importance is a function of the novelty and/or ambiguity of the situation" (Rotter, 1990, p. 59). He encourages the development of specific measures where appropriate but cautions that development time and cost precludes developing effective and valid measures for every specific area (1975). Carton and Nowicki add that any new scales must be based on a clearly described theoretical framework and be subjected to the same rigorous validation as previous generalized scales.

Another problem with locus of control research involves its inclusion in larger measurement scales. Most validated locus of control scales include at least twenty items. However, in many large-scale correlational and longitudinal studies there are so many variables in question that locus of control is often represented by only a few items on a much larger scale as opposed to a complete complement of locus of control items. There is not enough statistical evidence to conclude that the locus of control construct can be effectively measured with only a few items, so these larger studies must be looked at with some reservation.

These larger studies also point out another problem. Most of the large-scale studies, as well as many of the smaller ones, were carried out using nonexperimental research methods. While these studies provide interesting correlational information, they do not allow researchers to make causal inferences and thus limit the generalizations that can be made. Because of this, more experimental studies are needed in which locus of control is treated as an independent variable (Phares, 1976). In addition, as with the learner control research, interactional studies involving locus of control must make a greater distinction between treatment groups to effectively evaluate any interaction between locus of control and instructional strategy (Binette, 1992).

A final problem involves the terminology used in research studies. Locus of control is a well-known and validated construct. Yet, many researchers use the term *locus of control* to refer to *learner control*, even within the titles of their studies. While a case can be made for referring to learner control as locus of control (after all, it does involve the locus, or center, of external instructional control), this usage can only lead to misunderstanding. Rotter's locus of control construct has an enormous body of research to support it. Continued use of the term *locus of control* interchangeably with *learner control* will only undermine the importance of locus of control as its own unique construct.

Summary of Locus of Control Research

The preceding sections have presented a comprehensive review of the literature relating to the locus of control construct. Special consideration has been given to locus of control as a predictor of academic achievement and its potential interaction with various forms of learner control.

Several researchers have reviewed the literature on locus of control and academic achievement. Phares (1976) reviewed many studies that looked at the link between locus of control and achievement in children. He concluded that internal children were superior in their academic performance. He added that the relationship might be greater in children than in adults. Bar-Tal and Bar-Zohar (1977) reviewed more than 30 studies involving locus of control and academic achievement and found that most of them reported a positive relationship between an internal locus of control and achievement. They only found one study that indicated a negative relationship between internality and achievement. In their review of locus of control literature, Stipek and Weisz (1980) report that locus of control is generally correlated with both achievement test performance and grades. In most cases this relationship remains even when controlling for the effects of IQ.

Findley and Cooper (1983) reviewed the literature on locus of control and academic achievement to determine the strength and direction of the link between the two. In particular, they chose to look at studies that used adult populations in addition to studies that used younger populations. They reviewed 98 studies that included locus of control and achievement as relevant variables; those studies contained 275 hypothesis tests. An overwhelming number of the studies (193) reported positive findings. Of those positive studies, 126 were significant, indicating that greater internality was associated with greater achievement. There were only nine significant negative findings reported. The results of the analysis led them to conclude that locus of control and academic achievement are positively related. As Lefcourt (1982) states:

> The link between locus of control and cognitive activity appeals to common sense. In like fashion, common sense suggests that a disbelief in the contingency between one's efforts and outcomes should preclude achievement striving. Without an expectation of internal control, persistence despite imminent failure, the postponement of immediate pleasures, and the organizing of one's time and efforts would be unlikely. Common sense would dictate that these characteristics, essential to any prolonged achievement effort, will occur only among individuals who believe they can, through their own efforts, accomplish desired goals. Individuals must entertain some hope that their efforts can be effective before they can make the sacrifices that are prerequisites for achievement. (p. 81)

Although the research findings have not been unanimous, the consensus is that an internal locus of control is positively related to achievement. Any discrepancies in the findings merely points to the need to look at how locus of control interacts with various situational variables. Lefcourt adds:

> As in most instances, when a topic is closely scrutinized, the observed relationships are found to be anything but simple and conclusive. Nevertheless, it will be apparent that locus of control plays a mediating role in determining whether persons become involved in the pursuit of achievement. (p. 81)

In addition, an internal locus of control is related to other behaviors that increase the probability of success in academics (Bar-Tal & Bar-Zohar, 1977). Crandall and Crandall (1983) made several conclusions regarding locus of control. They stated that individuals with an internal locus of control are more active in searching their learning environment for information, have better cognitive processing and recall, learn more intentional as well as incidental material, select more challenging tasks, persist under difficulty, have higher achievement, make more attempts to prevent and remediate health problems, have better interpersonal relationships, are more liked and respected by others, have better emotional adjustment, and have greater reported life satisfaction. Roueche, Mink, and Abbott (1978) add that internals have a higher self concept, are generally better adjusted, more independent, more achieving, more flexible, more self-reliant, less anxious, show more initiative and effort in controlling the environment, and show more interest in intellectual achievement matters.

Conclusions: Locus of Control

Many students believe that no matter how hard they try they will fail for reasons beyond their control. They do not see the relationship between their efforts to succeed and the grades they receive, instead believing that teachers “give” grades. As a result, they refuse to take responsibility for their grades, do little to help themselves academically, and fail to learn course content. Locus of control attempts to explain the relationship between expectancy and behavior and gives researchers and educators knowledge that can help in the design of effective learning environments. Phares (1976) adds that the importance of the locus of control construct “lies in what it signifies about us as human beings. It tells us, through the force of the accumulated research, that belief in personal control can have widespread, important, and desirable outcomes” (p. 173).

Locus of control has been used in a variety of studies to help predict a variety of individual behaviors. Since its original introduction in the 1960s, there has been a great deal of research conducted using the construct. Other similar constructs have arisen in the years since then, including perceived control, self-efficacy, personal causation, helplessness, causal attribution, and personal competence (Lefcourt, 1992). Each of these constructs deals with issues of perceived causality and control, and there appears to be overlap in their definitions. Taken together, these constructs comprise an area of research regarding perceived causality and control. While this convergence of ideas will certainly contribute to the longevity of this area of research, locus of control remains an important construct due to its foundation in social learning theory and its unique approach to the study of human behavior. In fact, in a 1990 article Rotter reported that his original 1966 monograph had been cited more than 4700 times in the literature. He goes on to describe four propositions that contribute to the heuristic value of the LOC construct: its precise definition, its embeddedness in a theory of behavior, its methodological construction, and its initial publication as a thorough research monograph. Lefcourt concludes:

> That an area or construct is meaningful or ecologically valid and can be studied from many different vantage points, with many different instruments and methodologies, probably has much to do with the longevity of interest in any construct. I’m certain that these help to account for the continuing research activity evident in the locus of control literature. (p. 413)

Need for Study

There are two important categories of factors to consider when designing hypermedia-based instruction: *external* factors and *internal* factors. External factors are external to the student and are under the control of instructional designers. Learner control is an external factor because the provision or withholding of instructional control involves the external manipulation of various instructional strategies. Internal factors comprise internal learner traits and characteristics and are not under the control of instructional designers. Locus of control is an internal factor because it is a personality construct dealing with an individual's internal beliefs regarding the reinforcements that follow a behavior. The goal of this literature review has been to examine the external factor of learner control and the internal factor of locus of control and to ultimately discover their individual and combined potential for affecting learning from hypermedia-based learning environments.

There is a great deal of interest concerning the use of hypermedia in education. Materials can easily be developed that support student-centered learning, providing learners with powerful sources of information. In addition, learning with hypermedia can give learners an increased sense of control and increased motivation (Becker & Dwyer, 1994). Consequently, questions have continued to arise regarding the amount of control that should be afforded to the learner. Many previous studies have pointed to the ineffectiveness of increased learner control. While many of these studies were conducted using computer-based instructional materials, many of the results can probably be generalized to hypermedia instructional materials. After all, hypermedia can justifiably be thought of as simply a sophisticated form of computer-based instruction. However, hypermedia does have a number of unique attributes over old forms of computer-based instruction, and because learner control is so central to the effective use of hypermedia, research is needed that examines learner control from a hypermedia perspective. Williams (1993) suggests more research on learner control conducted in computer-based environments such as simulations, hypermedia, and distance education. This research should examine the unique attributes of hypermedia, such as (a) access to vast amounts of information, (b) networked structures, (c) nonlinear access, (d) hyperlinking and associative links, and (e) individual knowledge construction.

In addition, it is apparent from the research that issues involving learner control and hypermedia are greatly dependent on other variables, particularly those involving individual learner characteristics. Snow (1980) asks, “Can learner control be expected to overcome the persistent fact that individual characteristics *not* under control of the individual will determine to a significant extent what and how much that individual will learn in a given instructional setting? I think not” (p. 152-153). Individuals differ in their cognitive styles, personality characteristics, abilities, social skills, and motives. These internal variables can interact with the externally controlled instructional strategies to produce differential results across learners. Instructional designers can promote an improvement in the learning processes of individuals by designing instructional systems that best match the individual characteristics of the learners in their target audience. The key is to find out what combinations of instructional strategies and learner characteristics will produce the most effective and meaningful learning for each individual. Driscoll (1987) identifies a need for better Aptitude-Treatment Interaction (ATI) research. Researchers should focus on well designed and executed studies that will assist designers in developing effective instruction. She adds that there should be some theoretical basis for the aptitude used in an ATI study.

Locus of control has a strong theoretical backdrop and a large body of research that provides strong support for its value in educational research. Due to the nature of the locus of control construct, it seems logical to suggest that locus of control will play an important role in research involving hypermedia and learner control. However, there is a paucity of research that explores the issue of locus of control of students engaged in learning from learner-controlled and hypermedia-based environments. The studies that currently exist do not constitute a sufficient body of knowledge to allow researchers to make specific conclusions and prescriptions regarding locus of control, learner control, and hypermedia. This is an important consideration since hypermedia is ripe for creating constructivist-based, learner-controlled instructional environments. It seems likely that students with an external locus of control will have difficulty managing in these types of open environments without some sort of intervention and assistance, while students with an internal locus of control may welcome the added freedom. Moreover, the question remains as to whether or not complete learner control is best for any learner—even those with an internal locus of control.

Research Questions

Based on the preceding review of literature, several questions surfaced concerning the research on hypermedia, learner control, and locus of control. Of main interest was how learners' locus of control orientation might affect how well they perform in a hypermedia instructional environment in which differing levels of navigational control were afforded to them. More specifically, the following research questions were identified and provided the basis for the subsequent study:

1. Does the locus of control orientation of learners affect their performance in a hypermedia learning environment?
2. Does the amount of navigational control afforded to learners affect their performance in a hypermedia learning environment?
3. Do learners differing in locus of control orientation perform differently in a hypermedia learning environment when they are given varying levels of navigational control?
4. Do learners differing in locus of control orientation make differential use of associative hyperlinks?

Hypotheses

The preceding research questions were explored by conducting an experimental research study that investigated the use of three different forms of navigation within a hypermedia environment. Because hypermedia allows designers to create learning environments that afford learners a high degree of control over their learning, learners with differing locus of control orientations may perform differently under certain learner control conditions. Situations that require learners to exert more control over their learning may cause problems for learners possessing an external locus of control. On the other hand, learners with an internal locus of control may welcome a situation that allows them more control in how they explore the learning environment. Based upon a review of the literature concerning hypermedia, learner control, and locus of control, the following hypotheses were proposed:

1. Participants who use a branching navigational method to interact with a hypermedia instructional program will score higher on a posttest than participants who use a linear or networked navigational method.
2. Participants with an internal locus of control who receive hypermedia instruction will score higher on a posttest than participants with an external locus of control.
3. Participants with an internal locus of control who use a branching or networked navigational method to interact with a hypermedia instructional program will score higher on a posttest than participants with an internal locus of control who use a linear navigational method.
4. Participants with an external locus of control who use a linear navigational method to interact with a hypermedia instructional program will score higher on a posttest than participants with an external locus of control who use either a branching or a networked navigational method.
5. Participants with an internal locus of control will make use of associative hyperlinks more than participants with an external locus of control.

As evidenced in the hypotheses, it was expected that there would be differences in posttest performance between participants differing in locus of control orientation when exposed to hypermedia environments that required them to exert more or less control over their learning, as well as differences in how they made use of the options provided in the learning environment. In addition, based on previous locus of control research, participants with an internal locus of control were expected to perform better than participants with an external locus of control. Finally, due to the mixed results from previous learner control studies, it was expected that participants given a moderate amount of navigational control would perform better than participants given either little navigational control or a high amount of navigational control. Chapter II describes the methodology and procedures used in the study. Chapter III presents the results of the data analysis and a discussion of the results as they pertain to the research hypotheses.

CHAPTER II: METHODOLOGY

Introduction

The preceding research questions were explored by conducting an experimental study that investigated the use of three different forms of navigation within a hypermedia environment. Because hypermedia allows designers to create learning environments that afford learners a high degree of control over their learning, it was thought that learners with differing locus of control orientations might perform differently under certain learner control conditions. Situations that require learners to exert more control over their learning may cause problems for learners possessing an external locus of control. On the other hand, learners with an internal locus of control may welcome a situation that allows them to freely explore the learning environment. Cronbach and Snow (1981) stated, "The substantive problem before us is to learn which characteristics of the person interact dependably with which features of instructional methods. This is a question of awesome breadth" (p. 493).

This chapter outlines the methodology that was used to implement the present study. It includes a discussion of the participants, materials, procedures, and data analysis techniques that were used to test the research hypotheses.

Method

In this study, a 2 x 3 experimental design was implemented to explore the following variables within a hypermedia learning environment: locus of control and navigational (learner) control. Levels for each variable were as follows:

1. Locus of control: Internal or External
2. Navigational control: Linear, Branching, or Networked

Because past learner control studies have generally found insignificant differences between students in learner control and program control treatment groups, this study added locus of control as a possible internal learner characteristic that may affect performance in learner controlled environments. It was anticipated that this variable would help distinguish between those who do well in environments that afford them more control over their learning and those who do well in environments that afford them less control over their learning.

Participants

The population of interest for the study was college students enrolled in undergraduate courses at a major university. A sample from this population was obtained from students who are enrolled in undergraduate courses at Virginia Polytechnic Institute and State University (Virginia Tech). Students who participated were volunteers from one of several undergraduate English and biology courses offered at Virginia Tech. These classes were chosen because they were large, general knowledge courses required of all incoming freshmen. It was expected that a good heterogeneous mix could be obtained by using students from these courses. A total of 139 students initially signed up to participate in the study. From that initial pool, 15 were eliminated—13 based on their locus of control scores and two based on their pretest scores (see below). From the remaining 124 participants, 93 completed the entire experiment and were used as the basis for the statistical analyses. Of those 93 participants, 70 were female and 23 were male; they ranged in age from 18 to 23 years. See Appendix C for a copy of the Institutional Review Board approval letter.

As an incentive to participate, students who completed the study were entered into a drawing to win one of five monetary prizes—ranging from $25 to $300. After all treatments had been administered, a random drawing was held to determine the winners.

Materials

The main variables of interest in this study were locus of control, navigational control of hypermedia instructional materials, and posttest achievement. The measurement of each of these variables will be discussed in the following sections.

Locus of Control

Locus of control refers to an individual's expectancy or belief regarding the reinforcements that follow a behavior. Internal control refers to the perception of events as being a consequence of one's own actions and thereby under personal control. External control refers to the perception of events as being unrelated to one's own behaviors and therefore beyond personal control (Rotter, 1966). The locus of control orientation of an individual is generally measured by administering one of many specially designed scales. For this study, locus of control was measured using the Nowicki-Strickland Internal-External control scale for adults (ANSIE) (Nowicki & Duke, 1974). This scale provides a measure of individual differences in a generalized belief for internal versus external control of reinforcement. It consists of 40 items that are answered either yes or no; thus, scores range from 0 to 40. "The items describe reinforcement situations across interpersonal and motivational areas such as affiliation, achievement, and dependency" (Nowicki & Strickland, 1973, p. 149). Like Rotter's original instrument, the ANSIE scale is designed so that the higher a person's score, the more external their locus of control orientation.

The ANSIE scale is actually a derivation of the Children's Nowicki-Strickland Internal-External scale (CNSIE) (Nowicki & Strickland, 1973). The CNSIE was originally developed because the authors felt that there was a lack of an adequate scale for measuring children's locus of control orientation. The ANSIE scale was subsequently developed to eliminate some of the properties of the original Rotter scale that may have contributed to the inconsistent prediction of academic achievement behavior in college aged participants. The Rotter scale had been criticized for its relationship with social desirability, for confounding with different types of locus of control, and for its difficult reading level (Nowicki & Duke, 1974). The ANSIE is similar to the original Rotter scale but is geared more to students. It therefore retains the general nature of Rotter's instrument but adapts it to a student population. Lefcourt (1991) reported that a review of studies using the ANSIE indicated that most use has been with students.

The main difference between the CNSIE and the ANSIE scales is in the wording of some of the statements. With the ANSIE scale the wording is less targeted toward children. The items are readable at the fifth-grade level but are still appropriate for adults. Lefcourt (1991) asserts, "…its similarity to the CNSIE allows for study of developmental trends" (p. 431). Indeed, based on the CNSIE and ANSIE scales, a number of additional scales have been developed to measure the locus of control orientation in other populations. There are now derivations of the Nowicki-Strickland scales that cover preschool through geriatric populations, allowing the collection of data from different life stages. Lefcourt sees this as a definite advantage. "The ANSIE would seem to have certain advantages over the Rotter I-E scale, especially in its greater simplicity and its continuity with other NOSIE measures which allows for better comparisons in groups differing in age and status" (p. 432-433).

Reliability. Internal consistency reliability for the ANSIE has been determined using split-half and test-retest methods. Split-half reliability tests ranged from .74 to .86 (N = 158). The authors suggest that since the ANSIE test is additive and items may not be comparable, the likelihood is that split-half reliabilities will underestimate the true internal consistency of the scale (Nowicki & Duke, 1983). In fact, when discussing the internal consistency of his own general locus of control scale, Rotter (1975) stated, “Because additive scales such as this one sample widely from a variety of different situations, they cannot be expected to have as high internal consistency as a power scale that samples different strengths of response in a narrow area” (p. 62). In 1990 he added,

> We did not try for a high alpha (that is, the accepted measure of internal consistency) because we assumed that the correlations among different behavioral referents for the concept were positive but low. One can get very high alphas by asking the same question over and over again, but the predictive limitation of such a test are obvious. (p. 491)

Test-retest reliability for the ANSIE for a six week period was .83 (r = 83, *N* = 48) (Nowicki & Duke, 1974). Lefcourt (1991) also reported a test-retest reliability of .56 over a 1-year interval. Nowicki and Duke (1983) sampled studies that used the CNSIE and ANSIE scales and found that most estimates of internal consistency were over .60, a level they suggest is an acceptable level of internal consistency for a construct. As expected, test-retest reliabilities for the scales tended to be higher over shorter periods. “However, it appears that the CNSIE has acceptable test-retest reliability for periods as long as a year” (p. 16).

Validity. Convergent validity for the ANSIE was indicated by significant correlations with the original Rotter scale (ranging from .44 to .68), as well as correlations with anxiety, pathology, and achievement (Nowicki & Duke, 1974). Nowicki and Duke also reported significant correlations between the ANSIE and other locus of control scales (1983). Discriminant validity was indicated by results that showed that scores on the new scale were not related to social desirability scores, intelligence test scores, or gender (Lefcourt, 1991; Nowicki & Duke, 1974).

Validity for the ANSIE has further been established through the relationship of the scale to many different personality variables, particularly those that are considered positive social and socially agreeable characteristics (Nowicki & Duke, 1983). Finally, factor analyses have indicated that the scale measures a single large construct and not several smaller factors. “Factor analyses have often reported a large general factor, accounting for approximately 30% of the variance, that has been characterized as ‘helplessness’” (Lefcourt, 1991, p. 432). Other factor analyses have also found that general helplessness accounts for the greatest proportion of variance (Nowicki & Duke, 1983). Phares (1976), in support of the ANSIE scale, commented, “The ANS-IE scale measures achievement behavior. It is not related to either social desirability or intelligence. Further, it appears easier to read and understand than the I-E scale. Finally, it manifests suitable reliability” (p. 53).

Assignment of participants: A review of the studies involving locus of control reveals that the majority of researchers have used a median split to divide their participants into internal and external locus of control groups. This creates two even groups of internal and external participants. The problem with this method is that it creates a situation where there are participants near the median who could go either way by simply answering one or two questions differently. Participants whose scores fall just to the left or right of the median would be classified as if they are different in aptitude, even though their scores are close together. In addition, with this method of classification the differences between scores within groups can end up being very different. Cronbach and Snow (1981) use Figure 2.5 on page 26 of their book to illustrate this problem. Consequently, they feel that a simple median split wantonly discards power.

A number of researchers have tried to avoid this problem by using various methods to create a middle locus of control group. Many times this involves framing the middle group by moving one or one-half standard deviation from the median in both directions. Cronbach and Snow (1981) refer to this procedure as “blocking.” However, they do not feel that this is the best method to use. “We particularly discourage three-level blocking, i.e., forming high-, medium-, and low-aptitude groups prior to 2 x 3 anova. This loses power not only by disregarding within-block differences but also by disregarding the ordering of the three levels” (p. 27). Their analysis indicated that a study using three-level blocking has about the same power as a study using two-level blocking of the same cases at the median. They add later, “Investigators who have employed blocked anova have unnecessarily reduced the likelihood of rejecting the null hypothesis where it is false” (p. 61). They instead recommend taking high and low blocks of participants from the ends of the distribution. “Measuring an aptitude, dropping cases from the middle of the distribution, and randomly dividing cases in each of the tails to form the treatment groups produces a comparatively powerful design” (p. 59). This type of design “is appreciably more powerful than a study with the same *N* distributed over the full aptitude range” (p. 60). They suggest using the top and bottom third of scores.

In an effort to follow Cronbach and Snow’s (1981) suggestion, the present study used internal and external locus of control groups that were created by taking high and low blocks of participants from the ends of the distribution resulting from the ANSIE scores. The high and low blocks of participants were composed of the upper 45% of the distribution and the lower 45% of the distribution. Participants in the middle 10% of the distribution were considered neutral and were dropped from the study. For purposes of this experiment, participants whose scores fell in the upper 45% of the total pool of participants were classified as having an external locus of control. Participants whose scores fell in the lower 45% of the total pool of participants were classified as having an internal locus of control. It was expected that this method would allow a stronger case to be made that the participants in the study were truly internal and external. Several studies in the past (Gregory, 1976; Jones, Slate, & Marini, 1995; Pigge & Marso, 1994; Wesley et al., 1985) have used similar methods to create internal and external groups.

Notes on locus of control scales. Whatever method is used to create internal and external groups of participants, it should be kept in mind that locus of control is a scale and not a dichotomy. It is also important to keep in mind that the scores obtained using a particular instrument are relative to the population being studied. “It is very difficult to summarize the vast I-E literature and then present a “typical” I-E Scale score. Such scores vary significantly from study to study, from population to population, and from one point in time to another” (Phares, 1976, p. 45). Gray (1989), in discussing the results of her study, commented, “the wide range of mean locus of control scores, even in Rotter’s early studies, indicates that locus of control can best be viewed as a comparative measure within a very specific subpopulation” (p. 462).

Hypermedia Instructional Materials

The materials used to create the instructional treatments for this study were modified versions of materials originally developed by Francis M. Dwyer (1978). The materials consist of a 2000-word instructional lesson accompanied by images of the human heart. The instructional content involves the anatomy and functioning of the human heart dealing with the diastolic and systolic phases. The materials were originally created as a 21-page printed booklet, but with Dr. Dwyer’s permission, they were converted to a Web-based form for the current study.

Learner Control

Learner control can represent a variety of learning conditions. As is the case with locus of control, learner control is not a dichotomy; there are many control options that can be given to or withheld from learners. For research purposes, however, learner control as a variable is generally divided into two or three levels based on the amount of control afforded to learners. This study focused on one of the elements of an instructional environment that affords learners more or less control: the navigation structure. For this experiment, learner control was operationalized according the method used to navigate through the instructional materials.

The instructional materials developed by Dwyer were used to create three distinct hypermedia instructional environments. The instructional content was contained on a series of Web pages and accessed by participants using a Web browser. *The content in each environment was identical.* The difference was the method participants used to navigate through the content. Using different navigation structures allowed participants to have increasing amounts of control over the sequence in which they accessed the content. The differences between the treatments are described below. They were based on the navigation structures described by Lowe and Hall (1999).

Treatment 1: Linear navigation. In the Linear treatment, participants accessed the screens (nodes) of information sequentially. There were definite beginning and ending points, and participants advanced from one screen to another using “Next” and “Prev” navigation buttons. This sequence matches up closely with the traditional paper presentation of Dwyer’s heart materials. In addition, when participants reached the last content screen, they were presented with a button to take them to the posttest. Once a participant selected the test button, they were not allowed to return to the program.

This treatment provided participants with minimal control over the information in the hypermedia environment. They mainly had control over the pacing of the instruction. In addition, they had a limited ability to make connections between information contained on different screens. See Appendix D for sample screens from the Linear treatment.

Treatment 2: Branching navigation. In the Branching treatment, participants accessed the information using a hierarchical menu structure. The content was arranged in topics, and participants were able to access any topic in any order by making selections from a main menu. Selection of a topic provided access to the content associated with that topic. Using a navigation bar located at the bottom of each screen, participants were able to return to the main menu anytime they wished to reorient themselves or select a different topic. The navigation bar also allowed them to progress sequentially from one screen to another using “Next” and “Prev” navigation buttons (as in the Linear treatment). In this treatment, the button that allowed participants to advance to the posttest appeared at the bottom of the main menu screen. As before, once a participant selected the test button, they were not allowed to return to the program.

Control was increased in this treatment because participants had a choice as to which content they wished to access and the sequence in which they accessed it. See Appendix E for sample screens from the Branching treatment.

Treatment 3: Networked navigation. The Networked treatment was similar to the Branching treatment except that associative hyperlinks were added to each screen to increase learners’ options for navigating through the material. As in the Branching treatment, participants first accessed the information using a hierarchical menu structure, with content arranged in topics. Selection of a topic provided access to screens of information associated with that topic. All of the screens looked the same as they did in the Branching treatment, with the addition of carefully selected hyperlinks that were embedded within the content on each screen. These links connected information or concepts on one screen with related information or concepts on another screen. The use of embedded hyperlinks in a program allows information in the program to be connected to form a network of information, encouraging each learner to explore information in ways that make more sense to them (Jonassen, 1988). In addition, embedded links allow users to see how information they are currently viewing relates to information they may have encountered earlier.

When creating embedded links, the author has to find a compromise between providing few links, thus constraining the user, and providing too many links, thereby failing to concentrate on the most important associations and potentially frustrating the user. If a particular word is deemed important enough to use as an embedded link, it should not necessarily be linked everywhere it appears in the document but where the author thinks it is likely to provide the most benefit to users. For the present study, the Networked treatment was constructed so that any major terms introduced in one topic were linked to related concepts in other topics. At the same time, major terms that were used when describing important concepts were linked back to their initial descriptions. For example, if a term (such as *ventricle*) was introduced on one screen, and a reference was made to a heart function involving that term, an associative link was made to the screen describing that function. Conversely, if the content on a screen described a heart function and a major term was used in that description, an associative link was made to the screen where that term was initially defined. This provided a two-way process: terms were linked to relevant processes, and processes were linked to relevant terms. There were a total of 103 embedded links created throughout the program.

This treatment provided participants with the greatest amount of control over the information contained in the instructional environment. With the addition of associative links, users were provided with multiple ways to navigate through the material. Making use of the embedded links enabled participants to move horizontally through the program (across topics) in addition to moving vertically (within topics) and thus go beyond the topical arrangement of the content. Because of this, it should have provided the most opportunity for users to make meaningful connections between the information contained on different screens and perhaps establish new relationships between them. This type of browsing is believed to have a positive effect on learning (Spiro & Jehng, 1990). Packard, Holmes, Viveoris, and Fortune (1997) suggested that if students are allowed more choice as to how they access information, then differences between internals and externals may play a greater role. At the same time, this treatment posed the most risk of users becoming disoriented and/or frustrated due to the increased amount of linking. See Appendix F for sample screens from the Networked treatment.

Notes regarding all treatments. Participants in each treatment group viewed the same introductory screen, but were then presented with differing “start” screens. The Linear group saw a “Begin” button, while the Branching and Networked groups saw a main menu of options. As participants progressed through the materials, the content screens in each treatment looked identical except for any navigational tools specific to a particular treatment. For example, screens in the Linear treatment had navigation buttons at the bottom to allow users to advance to the next screen or return to the previous screen. Screens in the Branching and Networked treatments had an additional navigation option at the bottom to allow participants to return to the main menu at any time. Finally, screens in the Networked treatment included the embedded hyperlinks.

Controlling content exposure. Because participants in the Linear treatment group accessed the content in a sequential fashion, by default they were required to view all of the content screens. In contrast, participants in the Branching and Networked groups had a choice of which screens they viewed. This introduced a potentially confounding variable. It was possible that participants in the Branching and Networked groups would choose *not* to view all of the screens contained in the program. This could result in participants being exposed to different amounts of content. In an early study on learner control in computer-assisted instruction, Judd, Bunderson, and Bessent (1970) found that students allowed to control the sequence of instruction often skipped important content that was essential to understanding the topic. If this happened, any significant differences in achievement might be attributable to the differences in content exposure as opposed to the differences in locus of control or navigational control. For example, participants in the Embedded or Networked group who did not view Screen 7 could not possibly be expected to answer questions related to any content covered on that screen and would likely score lower on those items than participants who had viewed that screen. Because of this concern, the Branching and Networked treatment groups were set up so that participants were *required* to view all screens in the program at least once before being allowed to take the posttest. This helped to ensure equality of content exposure. They still had control over what order they viewed the screens in and how they navigated between them.

This control was implemented by having the computer keep track of the screens each person had viewed as they progressed through the program. After a participant viewed a screen, a check mark appeared in the main menu next to the link to that screen to indicate that the screen had been visited. In addition, a text notice appeared at the bottom of the menu screen informing the user of the number of screens viewed out of the total number available. The message was similar to the following: “You have viewed 5 out of 25 screens in the program. The screens you have viewed are checked off in the menu above.” This provided participants with a visual as well as a textual representation of their progress in the program. To prevent participants from taking the test until they had viewed every screen, the test button that appears at the bottom of the main screen was un-highlighted and inactive to begin with. When a participant had viewed every content screen at least once, the test button became active, and they were allowed to take the test at any time after that. Once a participant selected the test button, however, they were not allowed to return to the program.

Student Achievement

Student achievement was measured by a computer-based posttest administered immediately following the treatments. The test measured students on their ability to recall material that was covered in the program. Four types of criterion measures have been developed by Dwyer and his associates to accompany his instructional materials on the heart; these include a Drawing test, an Identification test, a Terminology test, and a Comprehension test. These instruments were designed to measure student achievement of different educational objectives (Dwyer, 1978).

Two of Dwyer’s assessments, the Terminology test and the Comprehension test, were used to measure student achievement in this study. The Terminology test consisted of 20 multiple-choice items that were designed to evaluate a subject’s understanding of terms and definitions pertaining to the heart. Dwyer (1978) feels that this type of test is applicable to any content area in which basic elements such as facts and definitions are a prerequisite to more advanced types of learning. The Comprehension test consisted of 20 multiple-choice questions that were designed to evaluate a subject’s knowledge of concepts related to the operational functions of the heart. Dwyer feels that this type of test is applicable to any content area in which the objective is to measure a learner's understanding of complex procedures or processes. Dwyer and Moore (1991) reported a KR-21 reliability coefficient of .83 for the Terminology test and a KR-21 reliability coefficient of .88 for the Comprehension test.

The scores from these two tests were combined to produce a total assessment score for each subject. This assessment score measured the overall achievement from the instructional program. In addition to the overall score, individual scores for each test were analyzed to determine if there were any significant differences related to the different learning domains. Taken together, these two tests provided an excellent measure of performance for learners interacting with the instructional content. Dwyer (1978) states, "for students to successfully engage in problem solving they need to be able to handle the basic terms, definitions, and facts of the discipline. They also need to be able to combine facts into concepts, concepts into generalizations, and so forth" (p. 43).

The remaining two of Dwyer's tests—the Identification test and the Drawing test—were not used in the present study because they deal more with visually-based outcomes. Considering the extra time commitment that would have been required of students, it was felt that the results on those tests would add very little to the scope of this investigation.

Experimental Interface

As part of this study, an interface was developed to assist with the implementation of the experiment. This came about because several of the procedures implemented in this study required computer assistance to effectively carry out. For example, customized computer programming was necessary to track participants' progress through the instructional program, limit participants' access to the posttest, and document participants' use of the embedded links.

As the design process moved forward, it was decided to go beyond the requirements of this study and create a more general interface that could be used to assist with a variety of tasks that are common to most experimental studies. In the end, it was designed as a general tool that can be used by other researchers in carrying out a variety of experimental studies. As an example, a typical experiment might involve a participant going through the following stages: (a) Sign up to participate, (b) complete a consent form, (c) complete a pretest, (d) sign up for an in-person treatment session, (e) complete the treatment, and (f) complete a posttest. The interface was designed to support researchers during each of these stages. It was developed with the assistance of a computer programmer and took approximately three months to complete and pilot test.

The completed experimental interface is actually composed of two parts: the researcher interface and the participant interface. For researchers, the interface allows them to (a) create studies with multiple stages, (b) implement survey- and test-based components of studies, (c) assign participants to treatment groups either randomly or manually, (d) schedule sessions for in-person stages of an experiment, (e) control participant access to different stages of a study, and (f) store and export all participant data (e.g., demographic data, survey and test scores). See Appendix G for sample screens from the administrative side of the experimental interface. For participants, the interface allows them to (a) sign up for a study, (b) submit a consent form, (c) complete survey- or test-based stages of a study, (d) sign up for in-person treatment sessions, (e) link to parts of a study conducted outside of the interface, and (f) contact researchers. See Appendix H for sample screens from the participant side of the experimental interface.

Procedure

The following section describes the procedures carried out during the implementation of this experimental study. It begins with a description of the pilot study, followed by a description of the two main stages of the study.

Pilot Study

Before commencing with the formal experiment, a pilot study was conducted to identify potential difficulties with the administration of the ANSIE, the environment in which the treatments would be administered, the content and structure of the computer based instructional materials, and the assessment instruments. Seven graduate students from Virginia Tech and three undergraduate students from a local community college participated. All of the students went through the process of logging into the experimental interface, signing up for the study, completing the locus of control survey and pretest, interacting with the instructional materials, and completing the achievement test. Two of the participants used the Linear treatment, four participants used the Branching treatment, and four participants used the Networked treatment. Feedback was gathered while participants worked through the instructional program and after they completed the study. They were encouraged to comment on the program and ask questions related to the procedures, instructions, screen design, and test questions. This feedback was used to improve the design of the experiment before its official implementation.

Several problems were identified as a result of the pilot study; most of them were related to the experimental interface and the heart treatments:

1. The tracking feature coded into the treatments did not properly track users when they clicked on the Web browser’s “Back” button.
2. The experimental interface incorrectly calculated the locus of control scores.

3. The survey and test features in the experimental interface did not require a user to answer every question before submitting their answers. This could have resulted in incomplete data for some users on the pretest, locus of control scale, or posttest. This was fixed so that users had to answer every question before they would be allowed to submit their answers.
4. Answers to survey or test items were appearing cut off if they were longer than 50 characters long.
5. The tracking feature did not register the last page a user visited before exiting a treatment.

All of these problems required adjustments to the programming code. The programmer was able to make the necessary changes before the full study was implemented. Several other features were added as a result of feedback from the participants in the pilot study:

1. A feature was added to the experimental interface that allowed the researcher to control the appearance of the link that takes participants to the final test. This helped prevent participants from accessing the test until they had completed their treatment.
2. An email link was added to the experimental interface to enable users to contact the researcher conducting a study.
3. A “Help” link was added to each of the heart treatments; clicking the link activates a popup window containing a review of the instructions for working through the program.
4. The labels on the navigation bar at the bottom of each content screen were changed from “next” and “back” to “next screen” and “prev screen.”

Stage 1 of the Study

To obtain participants for the study, several English and biology professors at Virginia Tech were contacted, and permission was obtained to solicit volunteers from a number of classes. Solicitation was carried out through in-person classroom visits, listserv postings, and email messages sent to a large number of students. In addition, flyers were posted in several campus buildings frequented by freshmen. In all cases, detailed information was given to students about how to sign up for the study. Students who wanted to volunteer were instructed to visit a Web site to sign up. Once at the Web site, they were asked to select a username and password, enter their contact information, officially join the study, and complete the ANSIE locus of control scale and pretest.

A total of 139 students signed up to participate in the study. These participants were administered the Adult Nowicki-Strickland Internal-External scale and the pretest. The ANSIE scale consisted of 40 items that were answered either yes or no. The pretest consisted of five multiple choice items dealing with the anatomy and functioning of the human heart. The ANSIE scale and pretest were presented to students on a Web page within the experimental interface. For each part, students selected their answers and then submitted a form; the results were then stored in a database for easy retrieval by the researcher.

The pretest was used to screen participants for prior knowledge of the subject matter used in the treatments. Those who correctly answered four or five questions were eliminated from the study. Two students were eliminated based on the pretest results. For the remaining 137 participants, scores on the ANSIE scale ranged from 2 to 25. The scores were used to classify participants as internal or external in their locus of control orientation. For purposes of this experiment, participants whose scores fell in the lower 45% of the total pool of participants were classified as having an internal locus of control. Participants whose scores fell in the upper 45% of the total pool of participants were classified as having an external locus of control. Participants in the middle 10% of the distribution were considered neutral. Based on the split, 62 participants were classified as having an internal locus of control orientation, 62 participants were classified as having an external locus of control orientation, and 13 participants were classified as neutral. The participants classified as neutral were dropped from the study; their data was not used in the subsequent statistical analyses.

To further ensure that the study was conducted with participants who could be considered internal and external, an independent t-test was carried out immediately following administration of the ANSIE scale to determine if the resulting internal and external groups had significant differences on their locus of control scores. The results of the t-test showed that there was a significant difference between scores in the upper group and scores in the lower group, $t(103) = -16.247$, $p < .05$. The results of the t-test are presented in Appendix I. Based on the significant results, it was concluded that the groups were different enough to be classified as internal and external.

An equal number of the participants from each locus of control group were then randomly assigned to each of the three learner control treatment groups: Linear, Branching, and Networked. This process was carried out using a set of random numbers generated using the Research Randomizer program available at http://www.randomizer.org. Consequently, this resulted in six experimental groups, classified as follows:

1. Internal locus of control / Linear navigation
2. Internal locus of control / Branching navigation
3. Internal locus of control / Networked navigation

4. External locus of control / Linear navigation

5. External locus of control / Branching navigation

6. External locus of control / Networked navigation

Figure 2 illustrates this relationship.

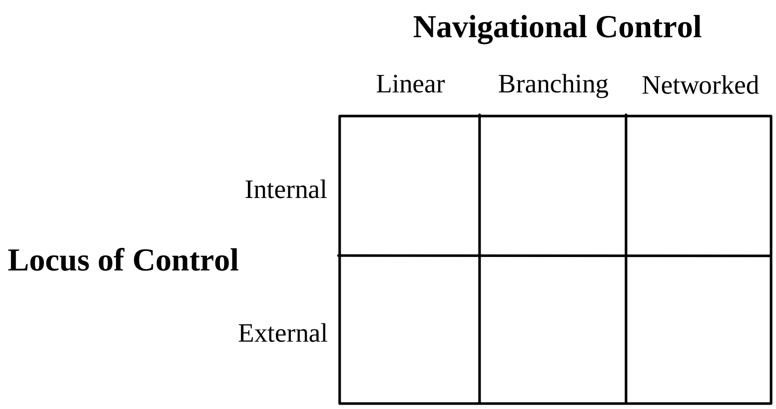

Figure 2. Graphical representation of treatment groups in 2 x 3 format.

It was expected that by using a fairly heterogeneous sample and randomly assigning participants to treatment groups, any significant results obtained would not likely have been caused by anything other than the differences in the treatments given to participants.

Stage 2 of the Study

Approximately one week before the experimental treatments began, those participants who had not been eliminated from the study were directed back to the experimental interface to sign up for a day and time in which to complete the second part of the study. Each session was scheduled to last one hour. Initially, four separate sessions were scheduled for each treatment, and participants were allowed to sign up for the session that best fit with their schedule. However, to better accommodate students' end-of-semester schedules, additional treatment sessions were added. The treatments were administered in the PC computer lab located in the Center for Instructional Technology Solutions in Industry and Education (CITSIE), located in

Room 220 of War Memorial Hall on the Virginia Tech campus. The lab allowed approximately 20 students to work independently at Windows–based computers. All participants taking part in a single session were administered the same treatment, although they may have had different locus of control orientations.

After arriving at the scheduled day and time, participants were instructed to sit at a computer of their choice. At the beginning of the session, participants received a detailed explanation outlining the examination process and were assured that all collected data would be kept confidential. Participants were informed that during the session they would interact with a computer-based instructional program and then take a test based on the material covered in the program. After a brief introduction to the instructional materials, participants were instructed to begin interacting with the hypermedia program. Each participant worked through the program independently at his or her own computer, with no interaction allowed between participants. They were allowed the remainder of the hour to work through the instructional materials and complete the posttest. When they finished, they were free to leave.

Treatments were administered over the course of about a month during the spring semester of 2004. In the end, 93 students out of 124 completed the entire experiment. They are represented by the data in this study.

Analysis of Data

Data for this study consisted of ANSIE locus of control scores, achievement scores on the three posttest measures, and link use scores for participants in the Networked group. All data was initially stored in a database and then retrieved to perform statistical analyses. Factorial ANOVAs were used to compare the means of participants in the locus of control and navigational control groups to determine any main or interaction effects. T-tests were used to compare the locus of control scores of participants who were classified as internal and external, as well as to compare the use of associative links by participants in the Networked treatment group. The programs StatView® and SPSS® were used to conduct all of the statistical analyses in this study. In all cases, significance was determined at the .05 alpha level.

Since t-tests and factorial ANOVAs were going to be used to analyze the data, certain assumptions about the population were checked first. The first assumption was that of homogeneity of variance. This was tested using Levene's statistic, and the nonsignificant results obtained on each test indicated that the variance of scores were comparable for all groups on each of the dependent measures. See Appendix J for the results of Levene's Test for each of the dependent variables.

The second assumption was that of normality. Distributions on the posttest were somewhat negatively skewed, both when looking at all of the data together and also when looking at the data for each group. While it cannot be stated with confidence that this assumption was met, the F-test is generally robust even if the assumption of normality is violated, particularly if the skewness is similar for all groups (as it was) (Howell, 1997). Therefore, the resulting analyses should be valid.

The final assumption was that of independence of observations. Since volunteers were used, the subjects may have been similar on one or more factors, or they may have possessed a personality characteristic lacking in non-volunteers. In addition, students were also allowed to pick which day they wanted to participate in the second stage of the study, so there is a possibility that they were grouped within treatment sessions according to some external factor, such as convenience or friendship. At the same time, the classes from which the volunteers were drawn were general introductory courses, which usually comprise students from varied backgrounds. In addition, students from numerous different classes were used so that they were not all coming from the same location. Most importantly, participants were randomly assigned to treatment groups, and all subjects went through the instructional material individually; there was no communication between students in any of the treatment groups. It was therefore concluded that this assumption was met as much as could be expected considering the nonrandom selection.

CHAPTER III: RESULTS AND DISCUSSION

Introduction

This chapter reports the findings of the study and any conclusions drawn from those results. The scores for each dependent variable are discussed followed by the results of the statistical analyses carried out to test each research hypothesis. The chapter concludes with an overall summary and conclusion.

The purpose of this study was to determine how learners' locus of control orientation might affect how well they perform in a hypermedia instructional environment in which differing levels of navigational control are afforded to them. Based upon a review of literature, the following research questions concerning the relationships between locus of control and learner control within a hypermedia learning environment were presented:

1. Does the locus of control orientation of learners affect their performance in a hypermedia learning environment?
2. Does the amount of navigational control afforded to learners affect their performance in a hypermedia learning environment?
3. Do learners differing in locus of control orientation perform differently in a hypermedia learning environment when they are given varying levels of navigational control?
4. Do learners differing in locus of control orientation make differential use of associative hyperlinks?

These research questions were explored by conducting an experiment that investigated the use of three different forms of navigation within a hypermedia environment. Because hypermedia allows designers to create learning environments that afford learners a high degree of control over their learning, it was expected that learners with differing locus of control orientations might perform differently under certain learner control conditions. Situations that required learners to exert more control over their learning might cause problems for learners possessing an external locus of control. On the other hand, learners with an internal locus of control might welcome a situation that allows them more freedom in how they explore the learning environment.

Results of Analysis

The following section presents an overview of the data collected for each of the dependent variables in the study. By the end of the experiment, four main scores were obtained for each participant:

1. ANSIE locus of control score
2. Total test score
3. Terminology test score
4. Comprehension test score

Participants in the Networked group had an additional score indicating the number of times they clicked on one of the associative links. All of the scores were automatically calculated by computer and stored in a database for easy retrieval.

ANSIE Locus of Control

As described earlier, the ANSIE scores were used at the beginning of the study to classify participants as internal or external in their locus of control orientation. In addition, the scores were analyzed using a t-test to determine if the resulting internal and external groups were significantly different on the locus of control measure. After that, the locus of control data was not used again.

Total Test Score

Data for the total test score consisted of numeric scores for each subject—categorized as interval for purposes of analysis. Total scores were based on the number of correct responses given on both the Terminology and Comprehension parts of the posttest. Scores ranged from 9 to 38 (out of a possible 40). The resulting scores were averaged to determine the mean and standard deviation for each of the treatment groups. The means, standard deviations, and overall totals are presented in Table 1.

Table 1

Means and Standard Deviations for the Total Test

		Locus of Control		
Navigational Control		Internal	External	Total
Linear	*M*	31.67	29.31	30.57
	SD	7.69	5.02	6.58
	n	15	13	28
Branching	*M*	30.30	29.29	29.88
	SD	7.35	6.38	6.88
	n	20	14	34
Networked	*M*	29.12	29.43	29.26
	SD	7.66	8.51	7.92
	n	17	14	31
Total	*M*	30.31	29.34	29.88
	SD	7.47	6.66	7.10
	n	52	41	93

A 2 x 3 (Locus of Control x Navigational Control) analysis of variance was conducted using scores on the total test to determine any main effects for locus of control and navigational control, as well as any interaction effect. Results of the factorial ANOVA indicated that there was no significant interaction between locus of control and learner control, $F(2, 87) = .248$, $p > .05$. In addition, there were no significant main effects for either locus of control, $F(1, 87) = .452$, $p > .05$, or navigational control, $F(2, 87) = .206$, $p > .05$. The results of the factorial ANOVA for the total test are presented in Appendix K.

Terminology and Comprehension Test Scores

Because Dwyer's Terminology and Comprehension tests measure different types of learning tasks, the scores from each test were analyzed separately to determine if there were any significant differences related to the different learning domains addressed by those portions of the test. The Terminology test evaluated participants' understanding of terms and definitions pertaining to the heart, while the Comprehension test evaluated participants' knowledge of concepts related to the operational functions of the heart. It was thought that differential effects might be observed for different treatment groups on the two measures. For example, internals might have performed better on the Comprehension test but not on the Terminology test. Many researchers have stressed the importance of recognizing that there are different types of learning and that different instructional strategies may affect learning differently depending on the type of learning one is interested in (Dwyer, 1978).

Total scores were based on the number of correct responses given on the Terminology and Comprehension parts of the posttest. Scores on the Terminology test ranged from 3 to 20 (out of a possible 20). Scores on the Comprehension test ranged from 4 to 19 (out of a possible 20). In each case, the resulting scores were averaged to determine the mean and standard deviation for each of the treatment groups. The means, standard deviations, and overall totals are presented in Tables 2 and 3.

Table 2

Means and Standard Deviations for the Terminology Test

		Locus of Control		
Navigational Control		Internal	External	Total
Linear	*M*	16.80	14.92	15.93
	SD	3.80	3.12	3.57
	n	15	13	28
Branching	*M*	16.15	15.00	15.68
	SD	3.77	3.53	3.67
	n	20	14	34
Networked	*M*	15.12	14.86	15.00
	SD	4.46	4.37	4.34
	n	17	14	31
Total	*M*	16.00	14.93	15.53
	SD	4.00	3.63	3.85
	n	52	41	93

Table 3

Means and Standard Deviations for the Comprehension Test

Navigational Control		Locus of Control: Internal	External	Total
Linear	*M*	14.87	14.38	14.64
	SD	4.14	2.84	3.54
	n	15	13	28
Branching	*M*	14.15	14.29	14.21
	SD	3.99	3.07	3.59
	n	20	14	34
Networked	*M*	14.00	14.57	14.26
	SD	3.77	4.59	4.10
	n	17	14	31
Total	*M*	14.31	14.41	14.35
	SD	3.90	3.51	3.72
	n	52	41	93

Results of a factorial ANOVA using Terminology test scores indicated that there was no significant interaction between locus of control and navigational control, $F(2, 87) = .318$, $p > .05$. There were also no significant main effects for either locus of control, $F(1, 87) = 1.806$, $p > .05$, or navigational control, $F(2, 87) = .389$, $p > .05$. The results of the factorial ANOVA for the Terminology test are presented in Appendix L.

Results of a factorial ANOVA using the Comprehension test scores indicated that there was no significant interaction between locus of control and navigational control, $F(2, 87) = .140$, $p > .05$. There were also no significant main effects for either locus of control, $F(1, 87) = .009$, $p > .05$, or navigational control, $F(2, 87) = .096$, $p > .05$. The results of the factorial ANOVA for the Comprehension test are presented in Appendix M.

Use of Associative Links

Past locus of control research has shown that externals traditionally prefer more structured arrangements, while internals are more receptive to open environments in which they have more control. However, it is unclear how this translates to a hypermedia environment. A study by MacGregor (1999) suggested that internally oriented students are more likely to make non-sequential connections when interacting with a hypermedia instructional environment. It is therefore possible that internals would make more use of the embedded hyperlinks utilized in the Networked treatment group. Because of this possibility, this study kept track of the number of times participants in the Networked group made use of the embedded links. Each click a participant made on an embedded link counted toward their total number. Scores ranged from 0 to 8. The means, standard deviations, and overall totals are presented in Table 4.

Table 4

Means and Standard Deviations for the Use of Associative Links

		Locus of Control		
Use of Associative Links		Internal	External	Total
Total	*M*	1.76	1.43	1.61
	SD	2.25	1.83	2.04
	n	17	14	31

An independent t-test was conducted using the link scores to determine if there were any significant differences between internals and externals in their use of embedded links. Results of the t-test indicated that there was no significant difference, $t(29) = .450$, $p > .05$. The results of the t-test for link use are presented in Appendix N.

Hypothesis Tests

The following section presents a summary of the results in relation to each of the research hypotheses. The results for each hypothesis are followed by a discussion of those results.

Hypothesis 1

Participants who use a branching navigational method to interact with a hypermedia instructional program will score higher on a posttest than participants who use a linear or networked navigational method.

The results of the factorial ANOVAs conducted using the total test scores, Terminology tests scores, and Comprehension test scores all indicated that there were no significant main effects for navigational control. The results did not support the hypothesis that participants in the Branching treatment group would score higher on a posttest than participants in the Linear or Networked treatment groups. It appears that the three navigational structures employed in this study had no effect on learners' performance in a hypermedia environment.

Discussion

Previous research into learner control has produced mixed results, with some studies indicating that individuals perform better when given more control over their instruction (Campanizzi, 1978; Gray, 1987; Hannafin & Colamaio, 1987; Hannafin & Sullivan, 1995; Kinzie et al., 1988; Milheim, 1990; Shyu & Brown, 1995), other studies indicating that individuals perform worse when given more control (Coldevin et al., 1993; Gray, 1989; McNeil

& Nelson, 1990; Paolucci, 1998; Pollock & Sullivan, 1990; Tovar & Coldevin, 1992), and a large majority of studies indicating no significant differences between the two (Burke et al., 1998; Coorough, 1991; Fredericks, 1976; Hicken et al., 1992; Murphy & Davidson, 1991; Pridemore & Klein, 1992; Quade, 1993; Schloss et al., 1988; Schnackenberg, 1997). Because of the conflicting results of previous studies, it was expected that any performance improvements in the current study would be seen in the middle navigational group (Branching). The results showed no differences, further adding to the mixed results in the area of learner control research. Thus, no instructional prescriptions can be made regarding navigational control.

Hypothesis 2

Participants with an internal locus of control who receive hypermedia instruction will score higher on a posttest than participants with an external locus of control.

The results of the factorial ANOVAs conducted using the total test scores, Terminology tests scores, and Comprehension test scores all indicated that there were no significant main effects for locus of control. The results did not support the hypothesis that learners with an internal locus of control would score higher on a posttest than learners with an external locus of control. Internals and externals achieved similar scores.

Discussion

There is a substantial amount of previous research showing that learners with an internal locus of control orientation achieve better than learners with an external locus of control orientation. Reviews of literature made by Phares (1976), Bar-Tal and Bar-Zohar (1977), Stipek and Weisz (1980), and Findley and Cooper (1983) have all concluded that there is a positive relationship between an internal locus of control and academic achievement. This relationship extends from childhood (Bartel, 1971; Nunn et al., 1986; Perna et al., 1983; Young & Shorr, 1986), through high school (Bar-Tal et al., 1980; Coleman et al., 1966), into college (Duke & Nowicki, 1979; Wuensch & Lao, 1975), and on to adulthood (Culver & Morgan, 1977; Findley & Cooper, 1983). Lefcourt (1982) states, "The link between locus of control and cognitive activity appeals to common sense. In like fashion, common sense suggests that a disbelief in the contingency between one's efforts and outcomes should preclude achievement striving" (p. 81).

While it may be true that learners with an internal locus of control orientation perform better than learners with an external locus of control orientation, the findings from the present study do not provide further evidence to support that conclusion. This was true for both the Terminology and Comprehension tests, as well as the overall test.

Hypothesis 3

Participants with an internal locus of control who use a branching or networked navigational method to interact with a hypermedia instructional program will score higher on a posttest than participants with an internal locus of control who use a linear navigational method.

The results of the factorial ANOVAs using the total test, Terminology test, and Comprehension test scores showed no significant interaction effect. Therefore, the results did not support the hypothesis that learners with an internal locus of control who used a branching or networked navigational method would score higher on a posttest than internals who used a linear navigational method. Internals scored similarly no matter which treatment they received.

Discussion

Many previous studies have looked at the interaction between locus of control and various instructional strategies. Internals perform better when advanced instructional strategies are used, such as adjunct embedded questions (Wilhite, 1986), self adaptive tests (Wise et al., 1994), or competitive tasks (Nowicki, 1982). Few of the previous studies, however, have looked specifically at the interaction between locus of control and learner control strategies. Related studies have employed strategies that would allow learners to exert more control over their learning or that required more effort on the part of the learners. Results have indicated that internals perform better in those types of situations (Allen & Harshbarger, 1977; Allen et al., 1974; Daniels & Stevens, 1976; Wright & DuCette, 1976).

There have been inconclusive results seen in learner control research over the years (Carrier & Williams, 1988; Niemiec et al., 1996; Steinberg, 1989; Williams, 1993). While learner control strategies may have mixed results when looked at alone, there may be personality characteristics or constructs that help explain the differences. Learners possessing certain characteristics may perform better when using certain learner control strategies, while learners possessing different characteristics may perform worse using the same strategies (Carrier & Williams, 1988; Clark, 1984; Coorough, 1991; Eom & Reiser, 2000; Yoon, 1993; Young, 1996). Williams (1993) concludes that there are “strong suggestions that a number of individual learner differences can greatly contribute to both the choices students make and to the effectiveness of those choices” (p. 2).

It was anticipated that locus of control might be one of the characteristics that could help explain the mixed results of learner control studies. In the present study, increased control was afforded to learners in the Branching and Networked treatment groups. As a result, it was expected that internals in those two groups would perform better than internals in the Linear group. However, internals performed equally well in all of the groups. Therefore, no suggestions can be made as to the best ways to accommodate internally oriented learners. Some studies have indicated that internals may do well in a variety of learning situations. They may be better able to adapt to unique situations and maintain a consistent achievement level. If this is the case, then internals may not need as much consideration as externals when designing instructional materials; they may be able to adjust regardless of the strategies that are employed (Allen et al., 1974; Cohen, 1982; Sherris & Kahle, 1984; Wright & DuCette, 1976).

Hypothesis 4

Participants with an external locus of control who use a linear navigational method to interact with a hypermedia instructional program will score higher on a posttest than participants with an external locus of control who use either a branching or a networked navigational method.

The results of the factorial ANOVAs using the total test, Terminology test, and Comprehension test scores showed no significant interaction effect. Therefore, the results did not support the hypothesis that learners with an external locus of control who used a linear navigational method would score higher on a posttest than externals who used a branching or networked navigational method. Externals scored similarly no matter which treatment they received.

Discussion

In a similar manner to the previous hypothesis, it was expected that learners with an external locus of control would be more comfortable using a linear navigational method and that this would result in improved scores. Previous research has indicated that externals prefer a more structured learning environment, with fewer options for controlling the content, sequence, or pacing of the instruction. However, in the present study, externals performed equally well regardless of the treatment. It appears that the type of navigational structure had no effect on learning. Therefore, no suggestions can be made for improving the experiences of external learners.

Because of the nature of the locus of control construct and the previous research, it is suggested that researchers continue to explore ways to improve the quality of learning experiences for learners identified as having an external locus of control orientation, particularly with regard to hypermedia instruction. Part of hypermedia's appeal is that it can be programmed to provide learners with many more choices in how they retrieve, process, and reuse information. However, because the strategies employed in hypermedia instructional situations are continually being developed and refined, it cannot be assumed that internals and externals will perform equally well in all hypermedia instructional situations.

Because hypermedia is flexible enough to present information in many different ways, it can be highly adaptable to individual cognitive needs. Previous research has shown that externals perform better in learning environments that contain more structure, require less decision making on their part, and provide more guidance (Allen et al., 1974; Daniels & Stevens, 1976; Van Damme & Masui, 1980; Wise et al., 1994; Wright & DuCette, 1976). While the strategies employed in the present study did not affect the performance of external learners, certain instructional strategies have been shown to help externals perform better. Examples of such strategies include math manipulatives (Cohen, 1982), advance organizers (Segal, 1974; Sherris & Kahle, 1984), increased guidance (Van Damme & Masui, 1980), immediate feedback (Nishikawa, 1988), and strategies that reduce stress levels in the learning environment (Collins-Eiland et al., 1986; Lefcourt, 1976).

Hypothesis 5

Participants with an internal locus of control will make use of associative hyperlinks more than participants with an external locus of control.

The results of the independent t-test using the link use scores showed no significant differences between internals and externals. The results did not support the hypothesis that learners with an internal locus of control would make greater use of embedded hyperlinks than learners with an external locus of control. Internals and externals made similar use of the embedded links that were provided in the Networked treatment group.

Discussion

Based on previous research, it was thought that internals might prefer and make better use of control options within the learning environment. This includes the associative links that were provided in the Networked treatment group. Past research on locus of control has indicated that people with an internal locus of control are more likely to be attracted to learning environments that provide them with greater freedom (Grabinger & Jonassen, 1988; Jonassen, 1985). In addition, MacGregor (1999) suggested that internally oriented students are more likely to make non-sequential connections when interacting with a hypermedia instructional environment. These non-sequential connections may reflect a schema-based model of learning and thus may provide options for learning that mirror the way that knowledge is stored in the brain (Jonassen, 1988). In theory, this should allow deeper cognitive processing and supposedly lead to greater retention of knowledge.

However, in the present study, internals did not make greater use of the embedded links. This may help explain why internals in the Networked treatment group did not perform better than internals in the other groups. While internals may be expected to perform better when using more advanced forms of navigation, in this study they did not choose to make use of the embedded links. Therefore, no differences could be expected based on that factor.

Conclusions

This study was designed to explore the interaction between the internal factor of locus of control and the external factor of learner control as they are both implemented within a hypermedia learning environment. Learner control was represented by the three navigational strategies: Linear, Branching, and Networked. It was expected that internals would perform better using advanced control options, while externals would prefer situations in which they did not have to assume as much control. However, the results indicated that internals and externals performed equally well under all control conditions. The results provide no support for the use of one type of hypermedia navigation over another, even when considering learners' locus of control orientation. Consequently, no predictions can be made regarding the navigational options that lead to improved performance for internally and externally oriented learners.

It is expected that researchers will continue to explore ways to improve the effectiveness of hypermedia learning environments. The options available to instructional designers who wish to create or make use of hypermedia materials are so varied that a single study cannot begin to consider the myriad of strategies that can be explored when conducting this type of research. In addition, because hypermedia involves dynamic structures of information and unique methods of navigating that information, learner control will likely remain an important consideration to those developing hypermedia materials.

The locus of control construct has come a long way since its initial proposal in Rotter's 1966 monogram. Since then, the construct has appeared in numerous studies encompassing many different research areas. Locus of control has a strong theoretical backdrop and a large body of research that provides strong support for its value in educational research. Due to the nature of the construct, one would expect it to continue to play an important role in research involving different learning strategies and conditions. Lefcourt (1982) describes a need for well designed experimental studies that seek to find out how the characteristics of the learning environment may mediate the relationship between locus of control and achievement. Nowicki (1982) concurs: “The type of situation probably plays some significant mediational role between people’s expectancies and their resultant behavior. Such is the case with the locus of control and achievement relation” (p. 158).

In closing, even though it was expected that learners with differing locus of control orientations would achieve differently under different learner control conditions, the results of this study did not match the predictions. While there may be opportunities for future research involving the variables of hypermedia, learner control, and locus of control, no further research is suggested by the results of this particular study.

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Appendix A: Summary of Learner Control Studies

Table A1

Summary of Studies on Learner Control and Achievement

Study	Subjects	Learner Control Variable	Results
Learner control of content			
Campanizzi (1978)	College students	Post-practice content	Achievement of students in the learner control group was significantly greater than the achievement of students in the program control group
Hannafin & Sullivan (1995)	Ninth- and tenth-grade students	Learner and program control; Lean-plus and full-minus	Students in the learner control group performed significantly better than did the students in the program control; no significant differences between full and lean groups
Hicken, Sullivan, & Klein (1992)	Students	Lean-plus and full-minus	No significant posttest differences between the learner control groups
Kinzie, Sullivan, & Berdel (1988)	8th grade science students	Post-practice content	Students in the learner control group performed significantly better on a posttest than students in the program control group
Schloss, Sindelar, Cartwright, & Smith (1988)	Students	Post-practice content	No achievement differences
Schnackenberg (1997)	Students	Learner and program control; Lean-plus and full-minus	No significant differences between learner control groups; Students in full group performed significantly better than those in the lean group
Learner control of sequence			

Coldevin, Tovar, & Brauer (1993)	College students	Three levels of sequence control	Students with the least control (linear) significantly outperformed those who were given more control
Coorough (1991)	College students	Control of sequence, practice, and advisement	No significant achievement differences
Gray (1987)	Students	Linear vs. learner control	Students under learner control performed significantly better on a test of immediate recall, but not on a retention test
Gray (1989)	Students	Control over branching	Students given less control over branching performed the best on both a retrieval task and a retention test
Hannafin & Colamaio (1987)	Students	Three levels of sequence control	Students in learner control and learner control adaptive groups performed better than students in the linear group
Milheim (1990)	Students	Control of pacing and sequencing	Significant differences due to pacing; no significant differences due to sequencing
Tovar & Coldevin (1992)	Students	Three levels of sequence control	Students in linear and mixed groups performed significantly better than students in the learner control group
Learner control of practice			
Fredericks (1976)	Students	Learner control over practice	No significant differences between program control and student control groups
Morrison, Ross, & Baldwin (1992)	Students	Learner control over practice; learner control of practice context	No significant differences for the context groups; students in the program control group (received all practice exercises) performed significantly better than

			students in the learner control group
Pollock & Sullivan (1990)	Students	Learner control over practice	Students in the program control group (received all practice exercises) performed significantly better on recognition posttest but not on recall posttest
Ross, Morrison, & O'Dell (1989)	College students	Learner control of practice context	No significant differences in achievement
Control over feedback			
Hines & Seidman (1988)	Students	Learner control over feedback; three types of feedback	No significant differences between any of the groups.
Pridemore & Klein (1992)	100 college students	Learner control over feedback; two types of feedback	No significant differences for learner control of feedback; students given elaborative feedback performed significantly better than students given only verification
Pridemore & Klein (1993)	College students	Learner control over feedback; three types of feedback	Program control group performed significantly better than the learner control group; students given elaborative or answer-only feedback performed significantly better than students given only verification
Adaptive control and learner control with advisement			
Arnone & Grabowski (1992)	101 first and second graders	Program control, learner control, and learner control with advisement	Students in the learner control with advisement group performed significantly better than students in the learner control group

Murphy & Davidson (1991)	Students	Learner control, adaptive, and advisement	No significant differences between the groups
Ross & Rakow (1981)	Students	Learner control over adaptive practice exercises	Adaptive treatment was superior to both the learner control treatment and the nonadaptive treatment
Shyu & Brown (1992)	Students	Program control and learner control with advisement	Subjects in the learner control group performed significantly better on the procedural skill
Shyu & Brown (1995)	Students	Program control and learner control with advisement	Subjects in the learner control group performed significantly better on the procedural skill
Tennyson, Park, & Christensen (1985)	Students	Learner control, adaptive, and advisement	Students in the adaptive group performed better on a retention test
Prior knowledge			
Gay (1986)	College students	Program and learner control	Significant interaction between learner control and prior knowledge. Students with low prior knowledge in the learner control group had significantly lower posttest scores than students in any of the other groups. Students with high prior knowledge performed equally well under both program and learner control conditions
Goetzfried & Hannafin (1985)	Low-achieving seventh grade students	Linear control, adaptive, and advisement	No significant differences for learner control groups
Relan (1995)	Students	Preinstructional strategy training; Limited (less practice) and Complete (more pratice) learner control	Significant interaction between learner control and training type. Students in the training+limited group performed better on an immediate posttest but not a

			retention test
Rowley, Miller, & Carlson (1997)	1277 high school students	Guided (low control) and Open (high control)	Students in the open group performed significantly better on a posttest
Individual learner characteristics			
Burwell (1991)	College students	Learner control and program control of content; field dependence-independence	Significant interaction. Field independent students performed significantly better in the program control group, while field dependent students performed significantly better in the learner control group
Carrier & Williams (1988)	Students	Control over elaborative material; high and medium persistence	High-persistence group performed best under learner control, while the medium-persistence group performed best under program control
Daniels & Moore (2000)	Students	Program control & learner control; field dependence-independence	No significant differences
Freitag & Sullivan (1995)	Adult learners	Full and lean groups; preferred amount of instruction	Subjects in the full control group performed better than subjects in the lean group
McManus (2000)	Students	Learner control and program control of content; level of self-regulated learning strategies; advance organizers	No significant differences
Yoon (1993)	Elementary school students	Program control, learner control, and learner control with advisement; field dependence-independence	Significant interaction between learner control and cognitive style. Field independent students performed significantly better in the learner control and learner control with

			advisement groups; field dependent students performed significantly better in the program control and learner control with advisement groups
Young (1996)	Seventh-grade social studies students	Learner control and program control of content; level of self-regulated learning strategies	Students with a low level of self-regulated learning strategies performed significantly worse in a learner control group than in a program control group. Students with a high level of self-regulated learning strategies performed the same in either control group
Learner control and student groupings			
Crooks, Klein, Jones, & Dwyer (1996)	Students	Full-minus and lean-plus; individual or group work	No significant differences
Crooks, Klein, Savenye, & Leader (1998)	Students	Full-minus and lean-plus; individual or group work	No significant differences
Hooper, Temiyakarn, & Williams (1993)	Fourth-grade students	Learner control and program control groups; individual and heterogeneous group work	No significant differences
Simsek (1993)	152 fifth and sixth graders	Learner control and program control groups; heterogeneous and homogeneous grouping	Students in the learner control group performed significantly better; students in heterogeneous groups performed significantly better
Singhanayok & Hooper (1998)	Students	Learner control and program control groups; individual or group work	No significant difference between the control groups; students in cooperative groups performed better than students working individually

Learner control and hypermedia			
Burke, Etnier, & Sullivan (1998)	Fifth-grade students	Linear vs. open navigation in hypermedia	No significant differences
Lanza & Roselli (1991)	Students	Low vs. high control in hypermedia	No significant differences
McGrath (1992)	Teacher education students	Hypertext, CAI, no-menu version of CAI, and paper-based materials	No significant achievement differences
Paolucci (1998)	Students	Low, moderate, & high control in hypermedia; active or reflective learners	Students in the moderate group performed significantly better; no significant relationships between learner control and cognitive style
Quade (1993)	Students	Linear vs. learner control in hypermedia	No significant differences
Shin, Schallert, & Savenye (1994)	Second-grade students	Limited-access vs. free-access in hypermedia; prior knowledge	Students with low prior knowledge performed better in the limited-access condition. Students with high prior knowledge performed equally well in both conditions
Yeh & Lehman (2001)	English as a foreign language students	Learner vs. program control in hypermedia; advance organizers	Students in the learner control group performed significantly better; Students in the advance organizer group also performed significantly better

Appendix B: Summary of Locus of Control Studies

Table B1

Summary of Studies on Locus of Control and Achievement

Study	Subjects	Results
Locus of control in different grade levels		
Bar-Tal, Kfir, Bar-Zohar, & Chen (1980)	2,438 ninth-grade Israeli students	Internals had greater achievement
Bartel (1971)	Children	Internals had greater achievement
Coleman et al. (1966)	High school students	Locus of control strongly related to the academic achievement, particularly with minority students
Daniel, LaBert, & Haydel (1993)	Seventh graders	Positive correlation between health locus of control and academic achievement
Duke & Nowicki (1979)	Male college juniors	Internals had greater achievement
Galejs & D'Silva (1981)	Nigerian children	Internals performed significantly better in language and mathematics
Maqsud (1983)	Nigerian children	Internals had greater achievement
Maqsud (1993)	Nigerian children	Internals had greater achievement
Nunn, Montgomery, & Nunn (1986)	268 students in grades five through eight	Significant correlations between internal locus of control and achievement in mathematics and language, as well as on the Iowa Test of Basic Skills
Perna, Dunlap, & Dillard (1983)	Emotionally disturbed boys aged 10 to 15	Positive relationship between internal locus of control and achievement
Pigge & Marso (1989)	Student teachers	Internals had greater achievement
Pigge & Marso (1994)	Student teachers	Internals were less anxious
Rupp & Nowicki (1978)	Hungarian children	Internals had greater achievement
Soh (1988)	Teachers	Internal teachers rated as more effective

		by their supervisors
Wuenach & Lao (1975)	College students	Internals had greater achievement
Young & Shorr (1986)	Fourth, fifth, and seventh graders	Internals had greater achievement
Locus of control in different subject areas		
Brooks & Hounshell (1975)	Elementary students	Internals scored significantly higher on science achievement tests
Culver & Morgan (1977)	College students	With Rotter scale, no correlation between locus of control and reading achievement; with Levenson scales, positive correlation between the internal scale and reading achievement, and a negative correlation between the external chance scale and reading achievement
De Santi & Alexander (1986)	Students	Internals had a significantly higher reading achievement level
Drummond, Smith, & Pinette (1975)	Community college students	Externals performed significantly better on a reading achievement posttest
Edwards & Waters (1981)	College students	No relationship between locus of control and scores on the verbal portion of a college qualification test
Mintzes (1979)	College biology students	No significant differences between internals and externals in biology achievement
Saunders-Harris & Yeany (1981)	Middle-school science students	Internals performed significantly better on a delayed retention
Large-scale studies		
Croucher & Reid (1979)	1000 nine and ten year olds	Internals had greater achievement
Darwazah (1998)	500 students	No relationship between locus of control and academic achievement
Keith, Pottebaum, & Eberhart (1985)	22,660 high school seniors	Internals had greater achievement

Prociuk & Breen (1973)	Students	No relationship between locus of control and academic achievement
Sterbin & Rakow (1996)	Over 12,000 high school students	Internals had greater achievement
Tesiny, Lefkowitz, & Gordon (1980)	944 fourth and fifth-graders	Internals had greater achievement
Wilhite (1990)	184 college students	Externals had greater achievement

Table B2

Summary of Studies Involving Locus of Control and Other Variables

Study	Subjects	Variables	Results
Instructional methods			
Fisher & Dyer (1978)	Freshman college students	Locus of control; hardware- or software-based reading improvement tools	Externals using hardware devices performed better than externals using software devices. Internals using software devices performed better than internals using hardware devices
McLeod & Adams (1980)	Students	Locus of control; level of guidance	No locus of control effects. Students in the high-guidance group performed significantly better on a math posttest and retention test.
McLeod & Adams (1980)	Students	Locus of control; inductive and deductive reasoning strategies	No locus of control effects. Students in the deductive group performed better on the posttest but not the retention test
McLeod & Adams (1980)	Students	Locus of control; individual or group work	Internals in the small-group treatment performed better and externals in the individual treatment performed better.

Nowicki (1982)	Children	Locus of control; competition or cooperation	Internals who competed against themselves or against another student performed better than externals in the same situation. When students had to cooperate with another student, internals and externals performed the same
Wesley, Krockover, & Hicks (1985)	Preservice elementary teachers	Locus of control; print and computer materials	No main effects. Externals who used the computer version performed better on the cognitive subscale
Yeany, Helseth, & Barstow (1980)	College students	Locus of control; interactive instructional video tapes	No significant results
Miscellaneous instructional strategies			
Cohen (1982)	Fifth-grade science students	Locus of control; access to manipulatives	Externals using manipulatives performed significantly better than externals not using manipulatives
Collinsd, Dansereau, Brooks, & Holley (1986)	College students	Locus of control; conversational noise	Internals exposed to noise during an instructional task performed better than externals who were exposed to the same noise
Moore & Dwyer (1997)	College students	Locus of control; color-coding of visuals	No locus of control effects
Segal (1974)	Students	Locus of control; advance organizers	Advance organizers had a significant facilitating effect on students with an external locus of control.
Sherris & Kahle (1984)	Students	Locus of control; advance organizers	Externals in the concept-related treatment group performed better on a retention test than external students in the control group,

			while internal students performed the same regardless of the treatment
Computer interactions			
Damme & Masui (1980)	Students	Locus of control; three instructional methods	Externals performed better when given more guidance
Nishikawa (1988)	Students	Locus of control; feedback strategy in CAI	Internals performed better than externals under the delayed feedback conditions
Wilhite (1986)	Students	Locus of control; adjunct questions	Internals using embedded adjunct questions performed better on a multiple-choice reading test than internals not using adjunct questions. There were no significant effects for externals
Wise, Roos, & Plake (1994)	Students	Locus of control; test type	Internals performed better with a self-adapted test, while externals were negatively affected by the self-adapted test
Yeany, Dost, & Matthews (1980)	College students	Locus of control; diagnostic-prescriptive instructional method	No significant results
Adult and Distance Learners			
Altmann & Arambasich (1982)	Adult students		Internals persisted more in adult upgrading program
Dille & Mezack (1991)	151 community college students		Internals more successful in a telecourse
Newsom & Foxworth (1980)	Adult learners		No differences between completers and

			noncompleters
Nord, Connelly, & Diagnault (1974)	Graduate business students		Internals performed significantly better in a variety of courses
Otten (1977)	Graduate students		Internals more likely to either obtain their doctorate degree or drop out within five years, while externals were more likely to still be working after five years
Parker (1999)	94 distance ed community college students		Externals more likely to drop out of the program
Taylor & Boss (1985a)	Adult learners		No differences between completers and noncompleters
Taylor & Boss (1985b)	Adult learners		Internals more likely to complete a community college adult basic education program
Wang & Newlin (2000)	Students		Internals more successful in an online course
Implicit learner control			
Allen & Harshbarger (1977)	Reading students	Locus of control; two methods of instruction	Internals performed better in a contract for grade plan than under a teacher-controlled method
Allen, Giat, & Cherney (1974)	Students	Locus of control; personalized instruction course	Externals performed poorer using the personalized instruction course
Daniels & Stevens (1976)	146 college students	Locus of control; two methods of instruction	Internals performed better in a contract for grade plan, while externals performed better under a teacher controlled method

Horak & Slobodzian (1980)	74 preservice teachers	Locus of control; structured and unstructured classrooms	Internals in the unstructured class performed better on a science content test, while externals in the structured class performed better
Johnson & Croft (1975)	Students	Locus of control; personalized system of instruction	No significant effects
Keller, Goldman, & Sutterer (Keller et al., 1978)	Students	Locus of control; personalized system of instruction	No significant effects
McMillan (1980)	Elementary students	Locus of control; two methods of instruction	No significant effects
Parent, Forward, Canter, & Mohling (1975)	Students	Locus of control; high- and low-discipline classrooms	Externals performed better under a high-discipline classroom condition, while internals performed better under a low-discipline classroom condition.
Root & Gall (1981)	Students	Locus of control; two methods of instruction	No significant effects
Wright & DuCette (1976)	100 elementary students	Locus of control; traditional and open classrooms	Internals in the open setting performed better. No significant results for students in the traditional classroom
Wright & DuCette (1976)	177 community college students	Locus of control; traditional and open classrooms	Internals in the open setting performed better. No significant results for students in the traditional classroom
Explicit learner control			
Carrier, Davidson, & Williams (1985)	65 sixth-grade students	Locus of control; lean, full, and options groups	Internals performed better in the full group
Coldevin, Tovar, & Brauer (1993)	Students	Locus of control; learner control of sequencing in interactive video	No effects for locus of control; students given the least amount of control performed the best

Gray (1989)	Sociology Students	Locus of control; learner control over branching	Internals performed better on a retrieval task - no significant differences on a retention test; students in review-only group performed better than students in total branching group
Holloway (1978)	Students	Locus of control; two methods on non-computer instruction	Internals performed better in the more open learning environment
Klein & Keller (1990)	Students	Locus of control; 2 levels of learner control (content, practice, and feedback)	No significant results
Lopez (1989)	Seventh- and eighth-grade students	Locus of control; 3 levels of learner control (practice questions and review screens)	No significant results
MacGregor (1999)	Seventh and eleventh graders	Locus of control; navigation in hypermedia	Externals tended to use the existing navigation structure, while internals were able to make more non-sequential connections
Packard, Holmes, Viveiros, & Fortune (1997)	Students	Locus of control; 3 presentation modes in hypermedia	No significant results
Santiago & Okey (1992)	Students	Locus of control; advisement	Internals performed better; students with adaptive advisement performed better

Appendix C: Institutional Review Board Approval Letter

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects)Chair
Assistant Vice Provost for Research Compliance
CVM Phase II- Duckpond Dr., Blacksburg, VA 24061-0442
Office: 540/231-4991; FAX: 540/231-6033
email: moored@vt.edu

DATE: March 16, 2004

MEMORANDUM

TO: David (Mike) Moore Teaching and Learning 0313
David Halpin

FROM: David Moore

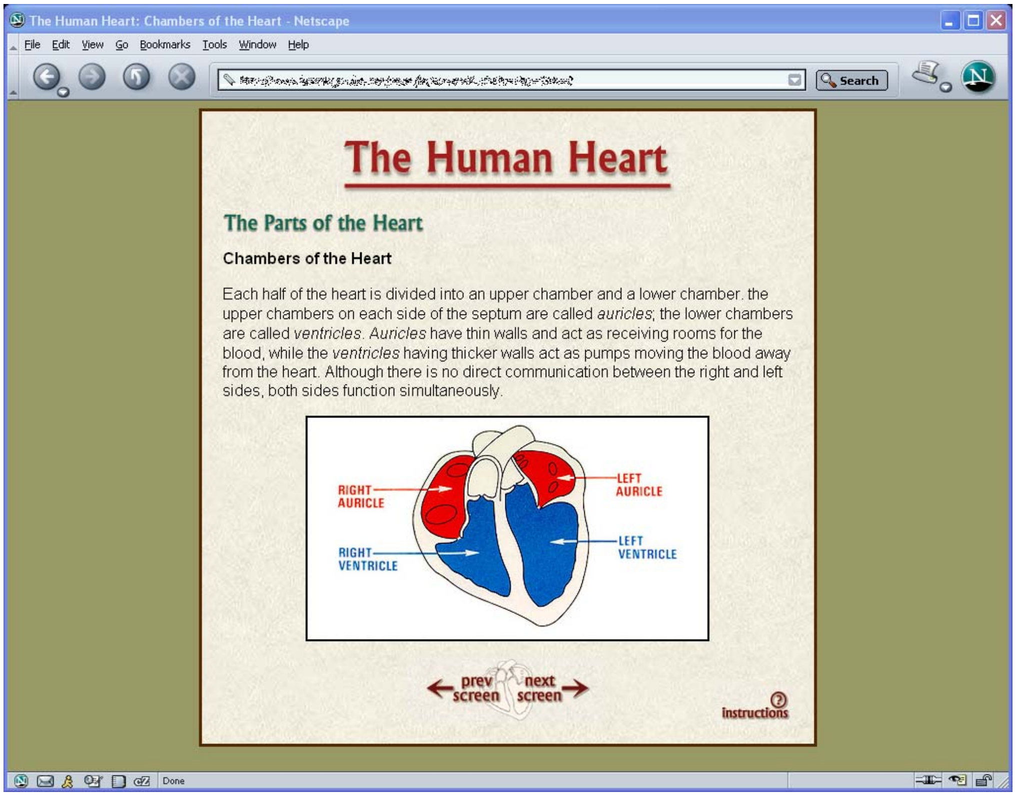
SUBJECT: **IRB Exempt Approval:** "The Effects of Locus of Control and Navigational Control on the Performance of Students in a Hypermedia Environment" IRB # 04-138

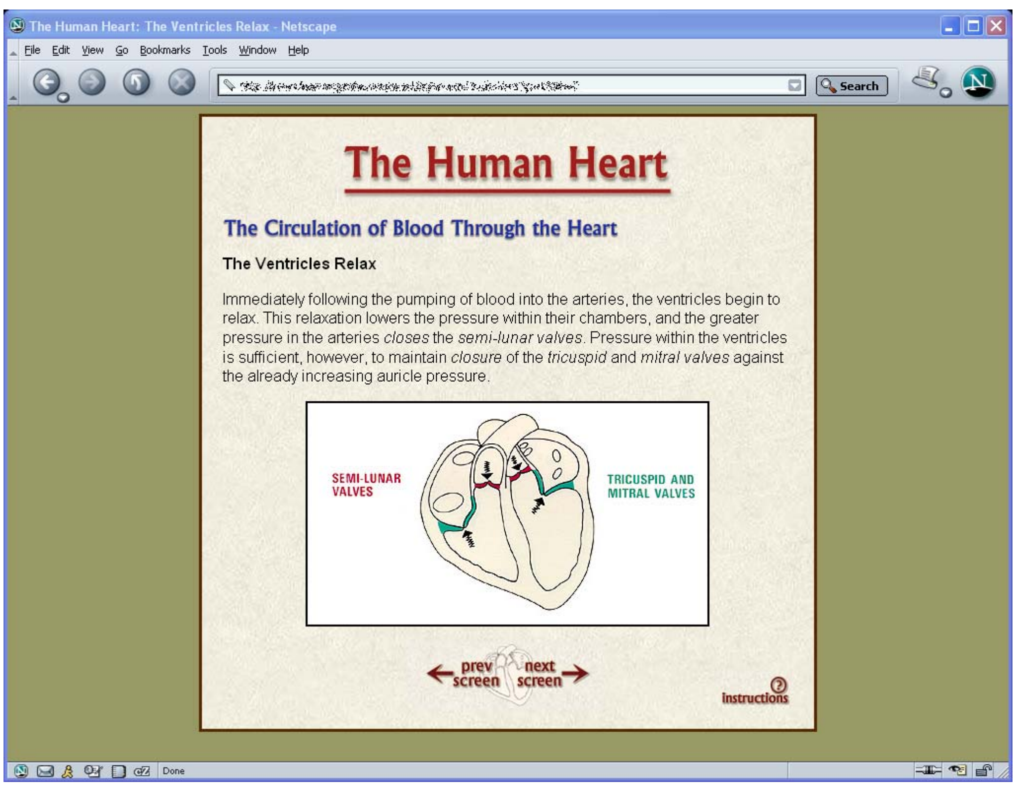
I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of March 12, 2004.

cc: File
Department Reviewer Barbara Locke T&L 0313

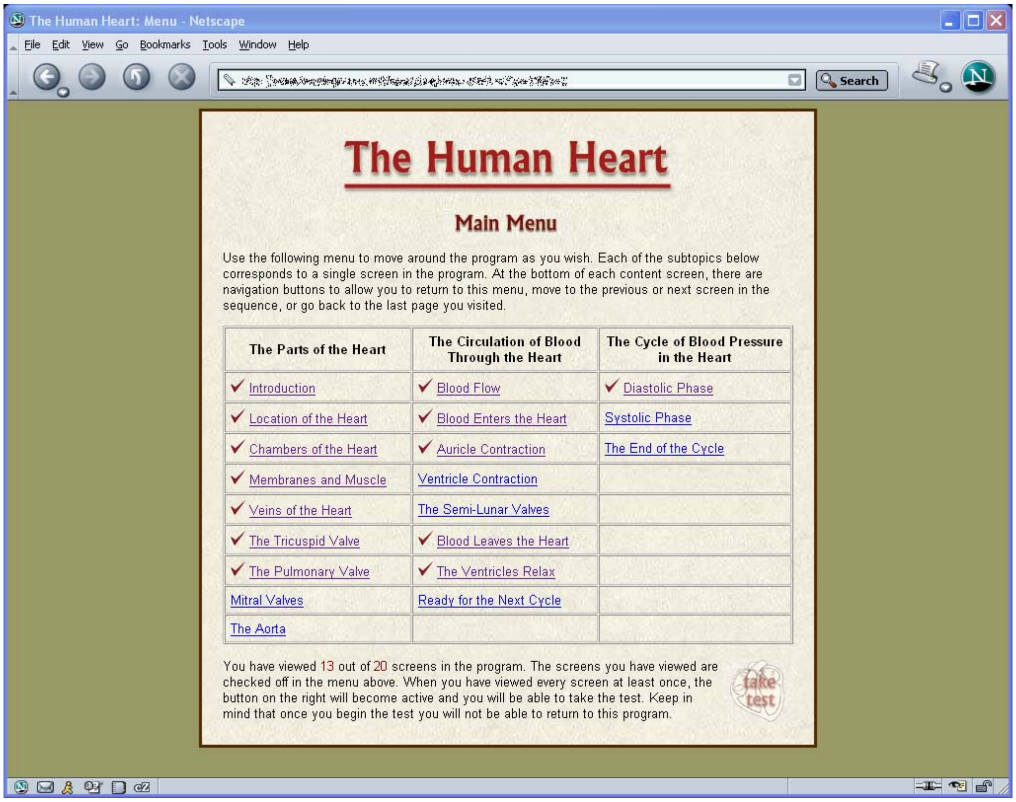
A Land-Grant University - Putting Knowledge to Work
An Equal Opportunity/Affirmative Action Institution

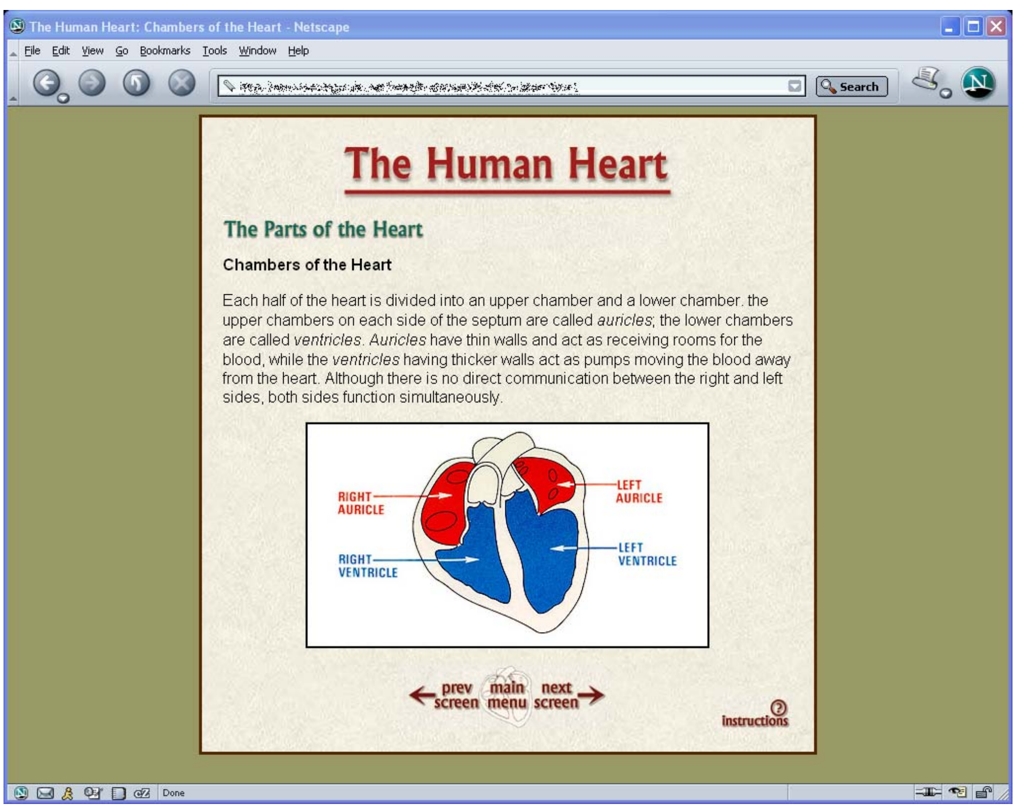
Appendix D: Sample Screens from the Linear Treatment



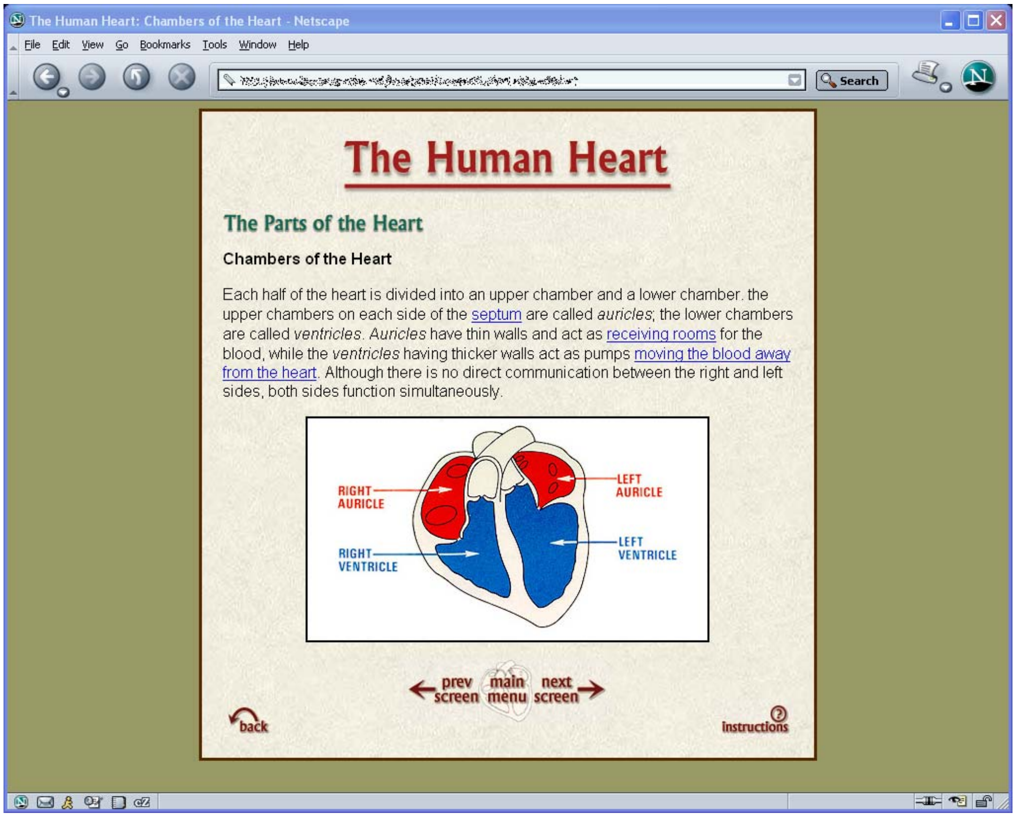


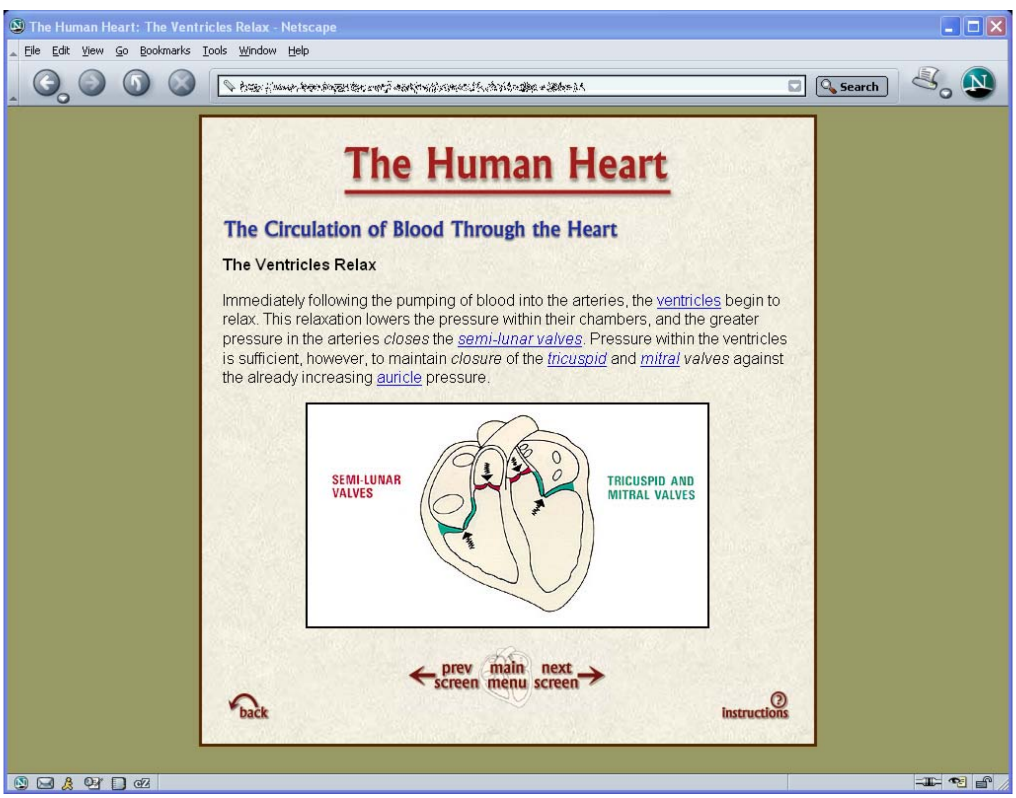
Appendix E: Sample Screens from the Branching Treatment



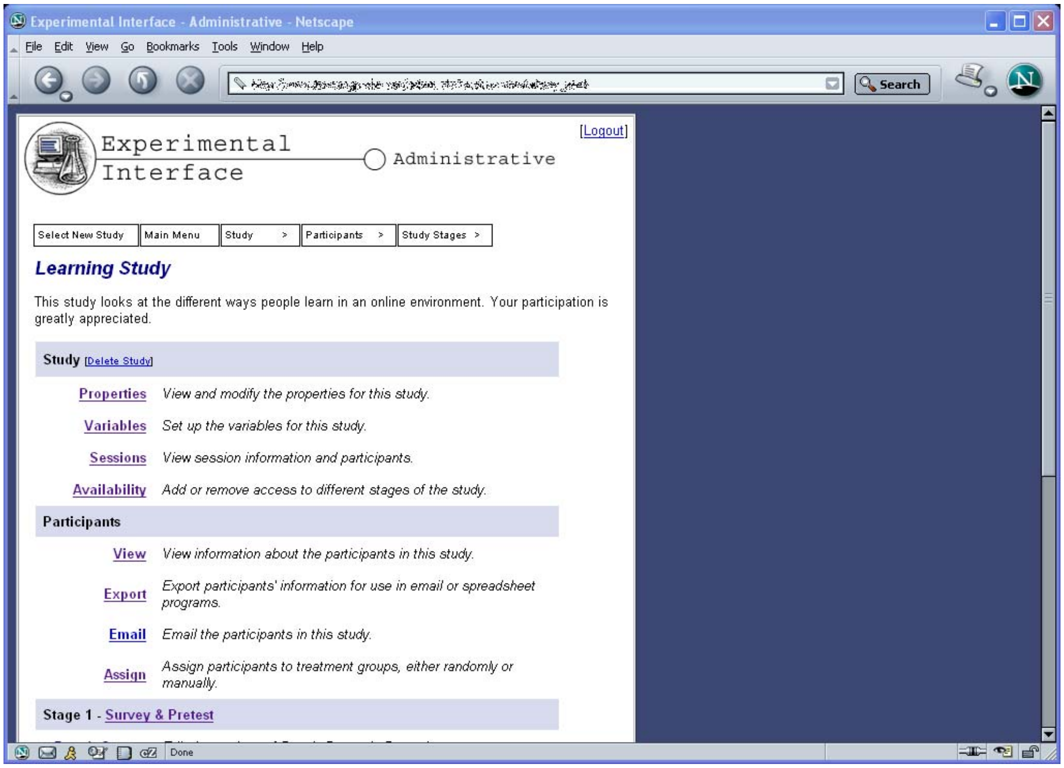


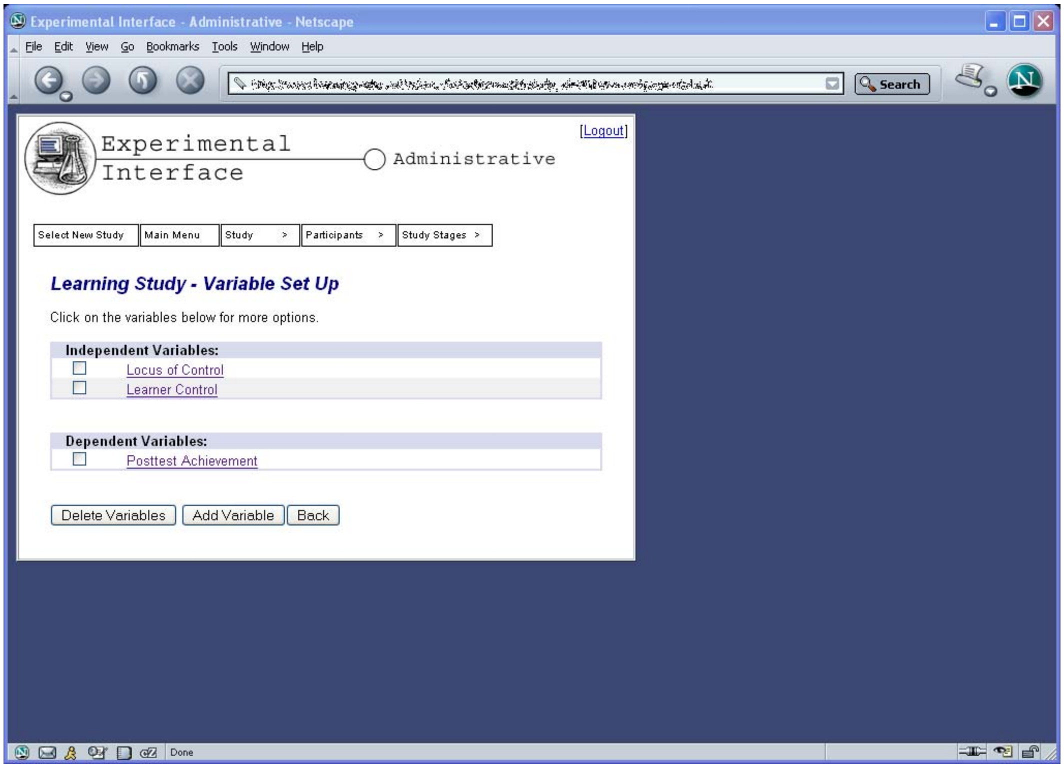
Appendix F: Sample Screens from the Networked Treatment



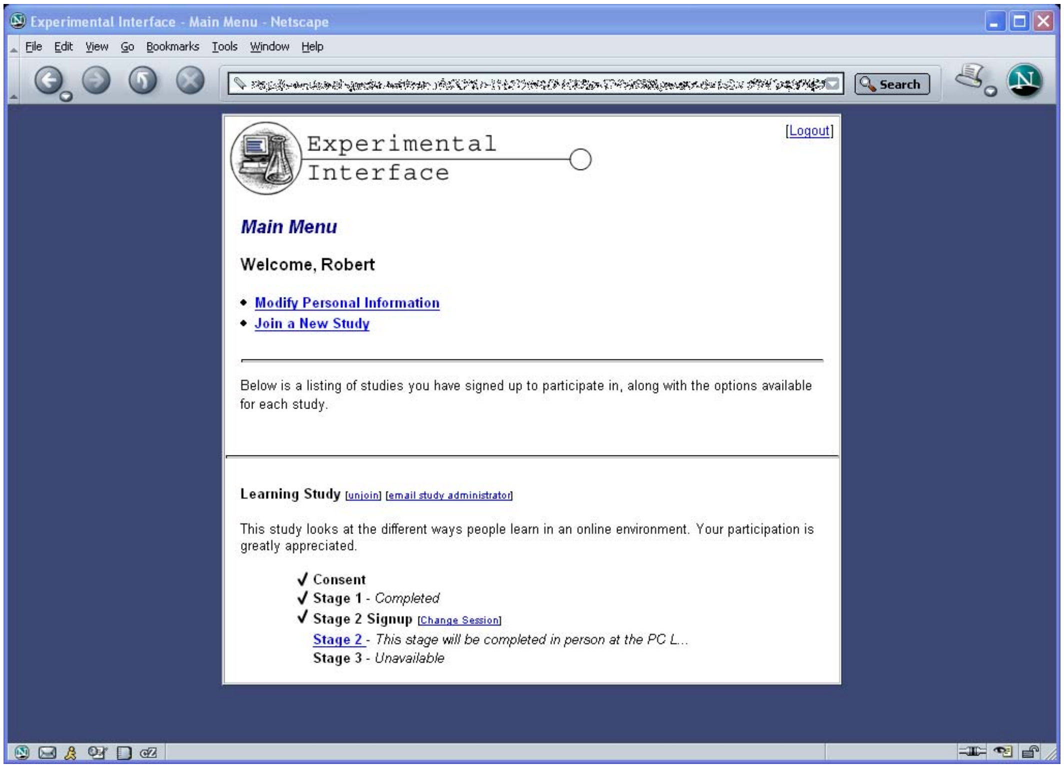


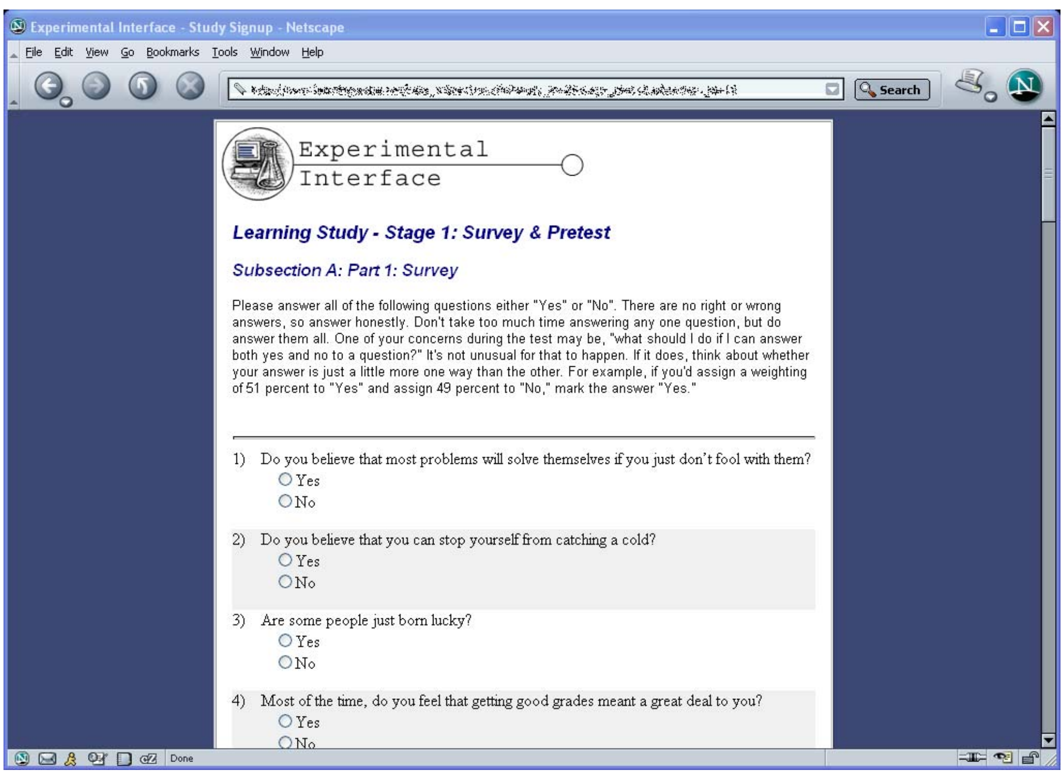
Appendix G: Sample Screens from the Administrative Side of the Experimental Interface





Appendix H: Sample Screens from the Participant Side of the Experimental Interface





Appendix I: T-Test Results Comparing Initial Locus of Control Scores

Locus of Control	*n*	*M*	*SD*	*t*	*DF*
Internal	62	7.08	2.03	.000*	122
External	62	14.87	3.19		

*$p < .05$

Appendix J: Results of Levene's Test for Homogeneity of Variance

Dependent Variable	*F*	Sig.	*df1*	*df2*
Total Test Scores	.413	.839	5	87
Terminology Test Scores	.520	.760	5	87
Comprehension Test Scores	.460	.805	5	87
Link Use Scores	.002	.963	29	

Appendix K: Summary ANOVA Table for Total Test

Source	*df*	*SS*	*MS*	*F*
Locus of Control (L)	1	23.73	23.73	.452
Navigational Control (N)	2	21.60	10.80	.206
L x N	2	26.05	13.02	.248
Error	87	4566.35	52.49	

Appendix L: Summary ANOVA Table for Terminology Test

Source	*df*	*SS*	*MS*	*F*
Locus of Control (L)	1	27.34	27.34	1.81
Navigational Control (N)	2	11.78	5.89	.389
L x N	2	9.62	4.81	.318
Error	87	1317.35	15.14	

Appendix M: Summary ANOVA Table for Comprehension Test

Source	*df*	*SS*	*MS*	*F*
Locus of Control (L)	1	.128	.128	.009
Navigational Control (N)	2	2.80	1.40	.096
L x N	2	4.08	2.04	.140
Error	87	1263.65	14.53	

Appendix N: T-Test Results Comparing Link Use in Networked Treatment

Locus of Control	*n*	*M*	*SD*	*t*	*DF*
Internal	17	1.76	2.25	.450	29
External	14	1.43	1.83		