

# Navigation Support for Learners in Hypertext Systems: Is More Indeed Better?

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**Abstract:** The non-linear nature of hypertext environments offers certain difficulties as well as opportunities for learning, thus making the design of such systems both complex and challenging. The flexible nature of hypertext makes it necessary for designers to provide learners with some kind of navigational support. Many hypertext systems, including adaptive hypermedia systems, emphasize navigation support, reducing the amount of exploration required by the learner as much as possible. By studying how guidance of the learner and the learner's exploratory behavior interact, it becomes clear that more guidance does not necessarily mean improved learning. We propose an approach based on meta-tools, e.g., image maps, and navigation support that emphasizes reflective activities.

## 1 Introduction

For centuries, people have been using texts to disseminate and acquire information. With the introduction of computers in the classroom, information that was hitherto available in printed form is now available electronically, in the form of hypertext documents. Hypertext is a network made up of non-linear units, in which text chunks (nodes) are related (linked) in multiple ways. The non-linear nature of hypertext environments offers certain difficulties as well as opportunities for learning, thus making the design of such systems both complex and challenging. The flexible nature of hypertext makes it necessary for designers to provide learners with some kind of navigational support. Researchers believe that learning from hypertext puts a greater

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cognitive load on learners [1]. Readers have to acquire specific strategies such as knowing where they are, deciding where to go next and building a cognitive representation of the network structure, in order to cope with the specific constraints of a non-linear presentation.

In traditional text, writers typically present a coherent set of arguments. The words, sentences and paragraphs flow together (local coherence) and the sections follow (global coherence) in a coherent manner. However in hypertext, it is more difficult for a writer to maintain global or macro-coherence (between sections), because there are numerous sections to which a learner can usually jump. Writers of hypertext thus have to define the information units and elaborate a web of semantic connections [2]. In addition, writers have to provide top-level representations to facilitate navigation and learning. Therefore, one of the most important aspects of hypertext design is that effective learning from hypertext is a cooperative venture between reader and writer. In a hypertext system, the reader is actively engaged in creating both meaning and structure. The reader constantly makes decisions about where to go next. Most systems constrain this choice with the goal of helping the reader make a good choice. An author of a hypertext may constrain and support the learner in various ways, for instance, by deciding which hyperlinks are available in a page (and which not!) or by the way the hyperlinks are ordered or prioritized in a list of suggestions or topics.

The question that arises then is how much of the structure should be predetermined by the author via navigation, i.e., with the way a reader may traverse the hypertext. A review of hypertext systems implies that the authors often impose a very strict structure thereby constraining the number of choices for the reader. However, if reader should be supported in actively creating both meaning and structure, she needs to be assisted by the writer. We suggest that the reader's learning process can be assisted with meta-level tools, rather than embedding the macro-structure within the text as in conventional writing.

In this paper, we will attempt to classify hypertext systems along several dimensions according to their navigation support. We are especially interested in the notion of 'more or less guidance.' We suggest that for educational purposes, less might be more, and that this approach has been largely been ignored by the hypertext system designers. We will then present an example hypertext system that uses a metalevel tool, a concept map, to provide support while at the same time enabling the learner to explore.

## **2 Existing Hypertext Systems**

A brief survey of a few representative hypertext systems will provide the background for our more general discussion of the characteristics of navigation especially with respect to how much navigation is needed and what "how much" means in this context.

According to Charney [3], text features such as organization and sequencing of ideas facilitate the development of well-integrated representations. Not surprisingly, making hierarchical relationships explicit has been one method used by researchers to facilitate learning from hypertext systems (e.g., [4, 5]). In studies by Dee-Lucas [4], providing structure had both advantages and disadvantages. On the one hand, readers used the structural information to build a representation of the text, while on the other, readers did not attend to the non-target content in highly structured overviews. Dee-Lucas suggests

that different types of overview structures may be appropriate for different types of learning objectives. Similarly, Shapiro [5] suggests that the structure of the hypertext system is critical to its educational value.

Kay and Kummerfeld [6] discuss their approach to personalized hypertext. In their system, which helps students learn C programming language, customization is offered based on background knowledge and language level. A user model allows for several levels of customization of exercises and examples.

Eklund and his colleagues [7] designed 'Interbook' to provide adaptive navigation support. According to them, "Interbook uses history based, knowledge based and prerequisite based adaptive annotation of links to suggest to the individual user an appropriate path through the learning space."

De Bra and Calvi [8], in their adaptive hypermedia system, AHA, have incorporated a user model that is created by reading pages of the system and taking tests. By generating content by what they call 'fragment variants,' the content of a page is adapted to the user model. They discuss the use of link annotation (color coding links) and link hiding, and also discuss the possibility of implementing link removal in their system.

De Vries [9] has used a means of adaptation in her system that involves the design of links based on students' learning goals. She created hypercard stacks for the domain of energy, based on an energy model (in consultation with experts). Each card was linked with three most related cards within the model. Students were given a question and were asked to select three cards that solved the criterion. Based on a study using this stack they built two new structures of hypermedia that students could use during problem solving. In this system they created an abstraction hierarchy and a cross-referenced abstraction hierarchy. According to de Vries, in the abstraction hierarchy, each screen presented an element on any one of three abstraction levels, and navigation took place from concept to performance requirement to materialization. The cross-referenced abstraction hierarchy permitted navigation within abstraction levels as well, e.g. an abstract concept was linked to performance requirements but also to other abstract concepts.

In summary, research in cognitive psychology based on text comprehension suggests that the effectiveness of a hypertext system depends much on its structure. But not just any structure seems effective for learning. As Dee-Lucas [4] found, inappropriate structures can have negative effects on the learner. All of the hypertext systems discussed address the issue of navigation explicitly. They all try to provide the best suggestions to the reader about where to go next in the network of text fragments. In other words, they all seem to implicitly assume that the more navigation support they provide the better and more useful the system is. It is also often unclear on what cognitive or pedagogical principles the method to suggest the "best" hyperlinks is based.

### **3 Continuum of Guided Exploration**

We will look at the issues of guidance and exploration and discuss what we mean by 'amount of navigation' and how it interacts with the reader's behavior. This will allow us to classify the existing systems and point out educationally interesting locations in the taxonomy that are currently void of hypertext systems.

Let's look at conventional texts before we move to hypertext. A regular book allows the user to jump to any page, paragraph, or even word at any time. Thus it can be viewed

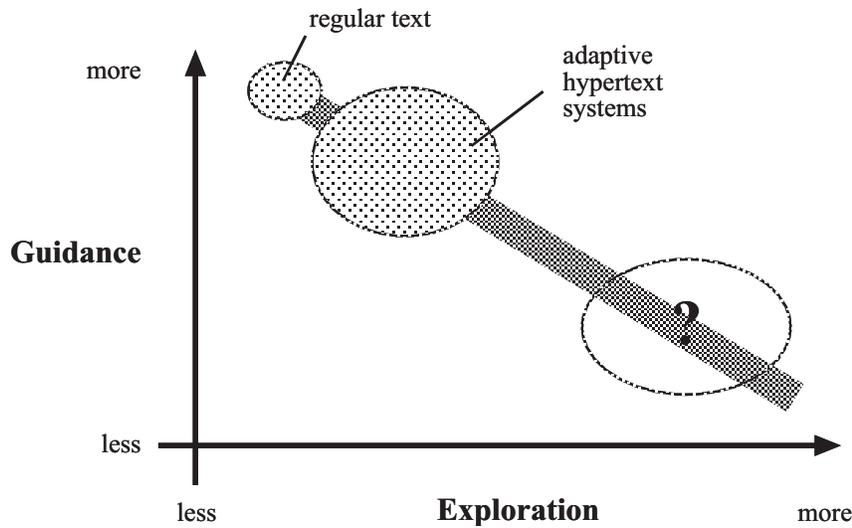


Figure 1: The 'guidance vs. exploration' diagram.

as a fully connected hypertext. However, people tend to read novels from the beginning to the end. This is due to the fact that a novel comes with an implicit prescription. We all learned in our childhood that a book is indeed read starting at one page, the page two, and so on. It is of course fine because the narrative structure of novels implies that it be read from beginning to end. But let us look at expository text. Novice readers are known to read them in a sequential order from beginning to end, but experts usually jump to sections. Thus, the book-as-hypertext is highly sequenced.

Adaptive hypermedia systems such as Interbook [7] or AHA [8] are similar to books in the sense that they generally suggest a relatively small set of possible next pages. Of course, the adaptive approach of these systems differentiates them strongly from books. However, there are still some more subtle differences. Adaptive hypermedia systems can make suggestions that are non-linear in nature. In a book, on the other hand, the user is constrained by the structure and the expectation of reading in an order. A second point is that in a book a person is free to overlook the structure because no one is telling her that these are the good choices, whereas in adaptive systems, the user is more prone to follow the choices presented by the system.

In web sites, hyperlinks present a choice where the user might want to go. Often, it is quite unclear to the user where a link really leads to, yet that's the only choice the reader has. A site map provides almost unconstrained access to any part of a site. Adaptive hypermedia systems attempt to solve this problem by computing the set of available links based on the users past behavior resulting in fewer choices.

First we address the issue of how guidance by the author and exploration by the reader interact and then how guidance can be influenced by how much choice and sequencing is provided to the reader

### 3.1 Guidance vs. Exploration

Users that are not completely familiar with an interface explore it to find out how it can be used to accomplish the users' tasks [10]. Users who know the interface well, will have a much more goal-directed behavior, generally selecting the correct action right

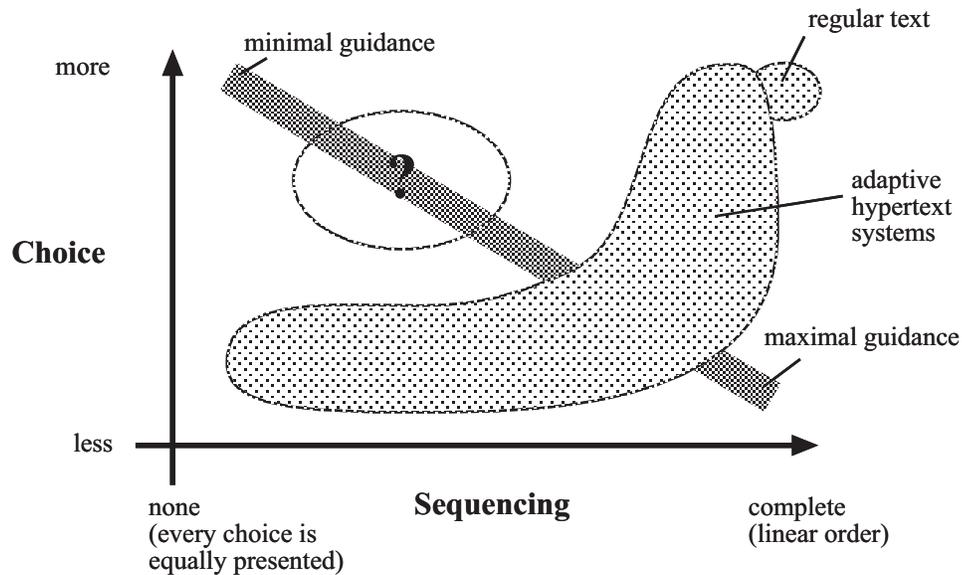


Figure 2: The 'choice vs. sequencing' diagram.

away. Reading a hypertext is similar to using an interface. A learner unfamiliar with the text will, if not constrained properly, explore the text much more than an expert who knows what to look for. This exploratory behavior should not necessarily be discouraged in an educational application. On the contrary, requiring the learner to make decisions about what will be important is an important part for becoming an effective learner.

As can be seen in Figure 1, most systems are on a diagonal where guidance is traded off for exploration. The more guidance is provided, the less exploration can be expected from the reader and vice versa.

As mentioned earlier, adaptive hypermedia systems attempt to guide the user through the thick of the hypertext network based on the user model that the system builds. Often, the goal of the system is to suggest the few best paths through the hypertext, although sometimes, all paths are made available in form of prioritized sequence. As the figure suggests, the current systems have not moved far away from the more traditional text.

We claim that area marked with a '?' should be considered more seriously for educational hypertexts where the reader is expected to learn new concepts and not just some facts. In a hypertext, very often the path selected reflects the learner's own goals and objectives. Hypertext technology is a powerful way to provide learners with support to select links that are meaningful to their changing goals and objectives. Therefore providing more guidance in the form of navigational support may not necessarily be better. Instead, learners require dynamic support, which will help them choose links based on their own learning objectives, and enable them to form well-integrated representations.

### 3.2 Choice vs. Sequencing

The concept of guidance needs to be further refined. First, we need to consider which and especially how many choices are made available to the reader, and second, how they are presented to the reader.

In a system where the user can go to any part at any time provides maximal amount of choice. An example is a fully linked hypertext system that always displays links to all



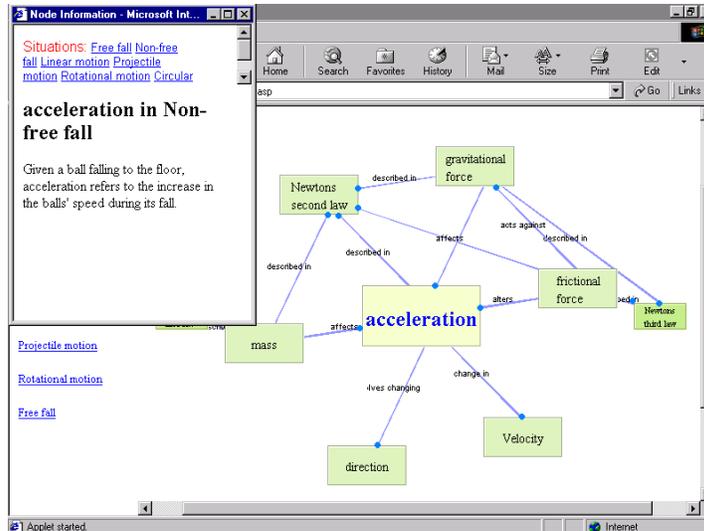


Figure 4: Concept map with 'Acceleration' as the focus.

more successfully supported with meta-level tools. An example of such a tool is described below.

## 5 Providing Metalevel Tools: An Example System

According to Novak & Gowin [11], concept maps are intended to represent meaningful relationships between concepts in the form of propositions. A concept map presents ideas in the form of nodes, which are linked by a word. Concept maps are very powerful in helping students see the numerous relationships between concepts, thus becoming an important meta-level tool for hypertext writers. We are using concept maps to build a hypertext system in the domain of middle school physics [12].

Our system uses a conceptual representation in the form of maps and a textual representation both of which change dynamically as students traverse through the domain and make choices. There are two problems with representing concept maps. First, it is conceptually difficult to represent maps with multiple relationships between numerous concepts. The maps have to be constrained in some way to enable students to read them. We have used 'situations' to constrain the domain into more meaningful components. We have organized the domain into several classes of situations such as Falling objects, Projectile motion, Linear motion, Relative motion, Circular motion, to name a few. For each situation, there is a corresponding conceptual as well as a textual representation of the relevant information. Second, a problem with representing large concept maps on the screen is that they do not scale up very well [13]. It is hard to display large maps with many relationships on a single screen, and showing part of the map results in a loss of context for the learners. Fisheye views [14] can be used to alleviate this problem.

In our system, the domain model consists of concepts and a network of binary relationships between the concepts. Each relationship has a certain strength where a greater strength implies a stronger relationship and a strength of zero is equivalent to having no relationship at all. The relationship strength is used to determine the spatial proximity of the concepts. Thus the stronger the relationship between the two concepts,

the closer they are spatially in the concept map. The maps are dynamically constructed and displayed with the fisheye. The concept that is chosen by a student is the focus, and the most related concepts are displayed closest to the focus. Relationship descriptors between concepts are displayed for the focus and the first level of magnification and not for all levels, to retain the clarity of the display (see figures 3 and 4).

## 6 Conclusions

Many existing advanced hypertext systems support the reader by providing guidance in the form of choices for navigation. We believe, that for educational use of hypertext, it is not obvious at all whether this is the right, or at least, the only way to go. A learner needs to negotiate what is important to them and what they ought to consider reading about next. This exploratory behavior will require reflective skills which are important for a good learner to have.

We therefore propose hypertext systems that provide navigation support at a meta level, thus avoiding having the reader blindly follow some link without reflecting about why this might be a good choice, i.e., why it probably will lead to a relevant piece of information. We therefore propose the use of meta-level tools as, for instance, concept maps.

Looking at the diagrams in Figure 1 and 2 and comparing the relationships between current systems, exploratory systems with meta-tools, and conventional text suggests that we still may be too strongly influenced by conventional text. Is a book still the best metaphor for hypertext or do we need to move on and find more radical models? And most importantly, have we as a community skipped a step by designing systems without really understanding non-linearity and how people process non-linear structures?

So far we have concentrated on providing structure. In the future we need to study what activities, including reflection, are required for students to process non-linear structures. Our approach, meta-level tools, is one answer. There may be others.

## Bibliography

- [1] P. Wright, "Cognitive overheads and prostheses: Some issues in evaluating hypertexts," presented at ACM Conference on Hypertext, 1991.
- [2] E. Esperet, "Notes on Hypertext, Cognition and Language," in *Hypertext and Cognition*, J. Rouet, J. J. Levonnen, A. Dillon, and R. J. Spiro, Eds. Mahwah, NJ: Erlbaum, 1996.
- [3] D. Charney, "Comprehending non-linear text: The role of discourse cues and reading strategies," presented at Hypertext '87, Chapel Hill, NC, 1987.
- [4] D. Dee-Lucas, "Effects of overview structure on study strategies and text representations for instructional hypertext," in *Hypertext and Cognition*, J. Rouet, J. J. Levonnen, A. Dillon, and R. J. Spiro, Eds. Mahwah, NJ: Erlbaum, 1996.
- [5] A. Shapiro, "Promoting Active Learning: The Role of System Structure in Learning from Hypertext," *Human-Computer Interaction*, vol. 13, pp. 1-36, 1998.
- [6] J. Kay and B. Kummerfeld, "Adaptive Hypertext for Individualised Instruction," presented at Workshop on Adaptive Hypertext and Hypermedia, User Modelling '94, Cape Cod, 1994.

- [7] J. Eklund, P. Brusilovsky, and E. Schwarz, "A study of adaptive link annotation in educational hypermedia," presented at TELECOM'98 - World Conference on Educational Multimedia/Hypermedia and World Conference on Educational Telecommunications, Freiburg, Germany, 1997.
- [8] P. De Bra and L. Calvi, "AHA! An open Adaptive Hypermedia Architecture," *The New Review of Hypermedia and Multimedia*, vol. 4, pp. 115-139, 1998.
- [9] E. de Vries, "Educational multimedia for learning and problem solving," presented at EuroAIED: European conference on artificial Intelligence in Education, Lisbon, 1996.
- [10] J. Rieman, "A Field Study of Exploratory Learning Strategies," *ACM Transactions on Computer-Human Interaction*, vol. 3, pp. 189-218, 1996.
- [11] J. D. Novak and B. D. Gowin, *Learning how to learn*. London: Cambridge University Press, 1984.
- [12] S. Puntambekar, A. Stylianou, and Q. Jin, "Visualization and external representations in educational hypertext systems," presented at AIED, 2001.
- [13] R. Hübscher and K. Jachimowski, "Sharing Large Concept Maps over the Internet," Demo at Computer Supported Collaborative Learning (CSCL'99), 1999.
- [14] G. Furnas and B. B. Bedersen, "Space-Scale Diagrams: Understanding Multiscale interfaces," *Human Factors in Computing Systems CHI'95*, pp. 234-241, 1995.