An Environment for Learning through Hypertext Construction

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Abstract *- Educational hypermedia systems provide a flexible style of accessing information and learning that is different from the strategies supported by traditional linear systems. As pointed out in previous research, both the content and the structure of a hypermedia homepage largely reflect the knowledge representation of its author. In the past, studies have been focused on how to construct a well-structured courseware with interesting and correct content, from the instructor's point of view. In this paper, we propose that constructing a hypermedia homepage can also be employed as a learning method.*

We first present a hypermedia courseware construction interface that provides the students a convenient authoring environment and supports effective recording and analysis functions behind the interface. The interface consists of three frames: a Knowledge Window, a Guidance Window, and a Content Window. It can be used under two authoring modes: Top-Down and Bottom-Up. According to the recorded information, we can understand how the hypermedia structures being constructed in a step-by-step manner, and consequently, how the authors transform their knowledge in their memories to hypermedia documents. The collected authoring patterns can be used for diagnosis and meta-cognition. Thus, these functions support an innovative approach for students to learn by building hypermedia, a type of constructive learning worth to be elaborately studied.

We designed instruction experiments based on the two authoring modes. We chose Natural Evolution as the learning topic and conducted a set of experiments. We defined three quantitative indicators to measure the structures and found their correlation to the authoring modes. We depict the results and give a brief discussion in this paper.

I. Introduction

Along with the development of the Internet and the World Wild Web (WWW) platform, there are more and more hypermedia courses available on the network. Instructional materials are stored and presented on the nodes that are connected to each other through the use of hyper-links. In this form of cross-reference, information is presented in a nonlinear manner, as pointed out by Conklin (1987), which is different from traditional instructional media such as text and video. Hypermedia courseware enables us to construct and retrieve knowledge in a way more natural for human thinking than before (Balasubramanian, 1995). Consequently, how to apply hypermedia to improve learning has become a hot topic in the past few years.

Previous research indicated the importance of authoring tools. A friendly interface for teachers to edit multimedia content and to browse the hypertext document under development is critical for the success of hypermedia courseware (Garzotto, Paolini, & Schwabe, 1993). We designed and implemented an editing tool called CORAL-Chain, which put emphasis on the construction of hyper-links. We believe the structure of a hypermedia document and the process of its development largely reflects the knowledge framework of its author (Sun, Chou, & Lin, 1998).

Navigation guidance tools are important for browsing via hyper-links so that one can avoid being lost in the hyper-space (Shneiderman & Kearsly, 1989; Nielsen, 1989). As a matter of fact, we found that they are also essential for constructing hyper-links because authors need to know the global structure of connected hypermedia nodes as well as the local relationship between them. Thus, global and local tracking guidance tools were provided. Moreover, logging functionality was embedded in CORAL-Chain so that the construction process of authors can be recorded for later analysis.

The tool was used to develop a series of instructional experiments conducted in the CORAL (Cooperative Remotely Accessible Learning) environment. The primary goal of this study was to identify general patterns in hyper-link-based knowledge construction. We will then investigate the possibility of using hypermedia construction as a constructivist learning strategy. The goals of constructivist pedagory, as pointed out by Simons (1993), include active learning, constructive learning, cumulative learning, goal-oriented learning, diagnostic learning, and reflective learning. We believe that the approach proposed in this paper can realize these goals to a certain extent.

II. Interface Design of CORAL-Chain

The editing interface of CORAL-Chain is divided into three windows: a Knowledge Window, a Guidance Window, and a Content Window, as shown in Figure 1. The file names of all the nodes (HTML files) under editing are listed in the

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Knowledge Window (upper-left). The content of the current edited node is shown in the Content Window (Right). All nodes linked to the current node, to or from, are shown in the Guidance Window (lower-left). We found that the local tracking map demonstrated in the Guidance Window especially helpful because the author can see not only those nodes referred by the current node, but also the nodes referring to the current node. The former ones are visible in the content of the current node, the latter ones are equally important but implicit in the structure under development. We believe this design helps the author building a mental framework of the whole courseware structure, instead of focusing on the content of individual nodes. This is especially true when some of the nodes come from other sources, for example, in a co-authoring environment.

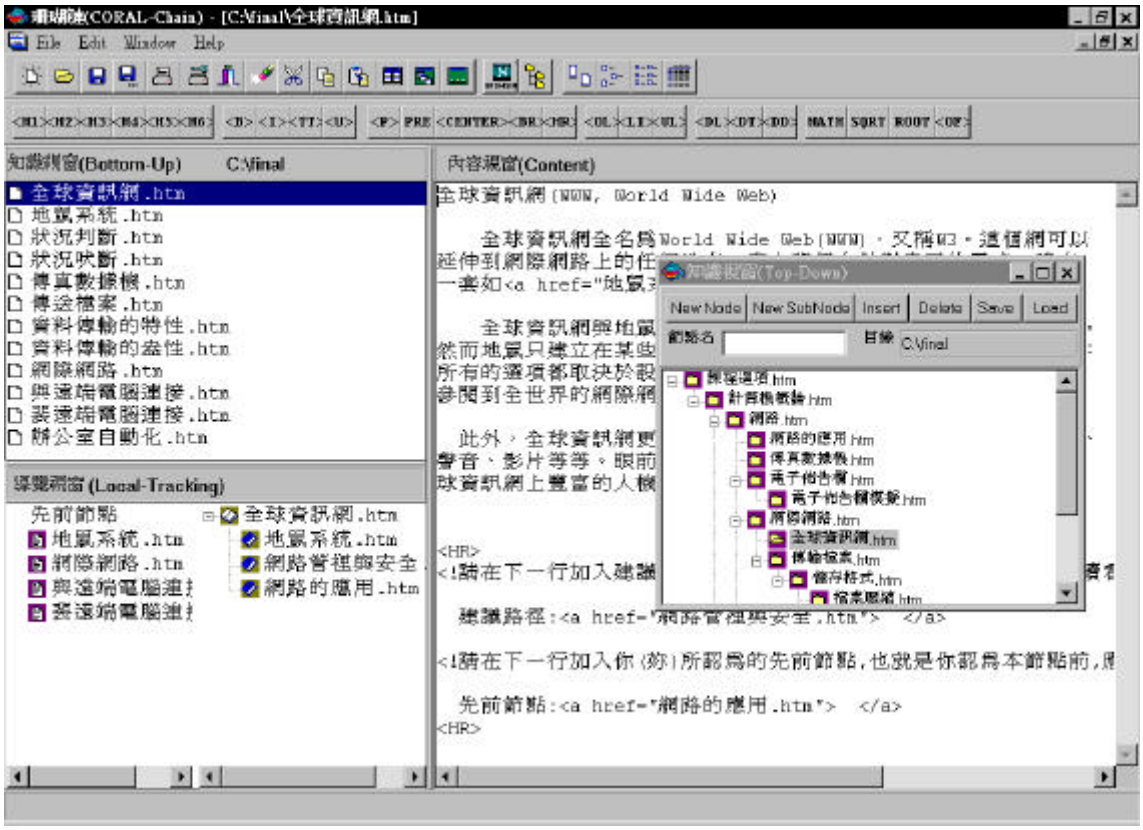

Figure 1. Editing Interface of CORAL-Chain. The file names and content are in Chinese.

Based on the interface described above, we designed two construction modes for the author to choose. The first mode, Bottom-Up, is used when a collection of nodes with existing content are available and the task to be done is to add links between them. The second mode, Top-Down, is used when the structure is designed by the author first, then the content is filled in individual nodes. Of course these two modes can be employed in a switching manner. We conducted experiments on the two constructing modes by providing the subjects different forms of material at the beginning of the experiments, as described in the next section.

III. Design of Experiments

We conducted instruction experiments on 34 students from an undergraduate class. They were asked to construct a homepage on Natural Evolution. The material was given, what they needed to do was adding hyper-links. The subjects worked under different modes: (a) Top-Down, (b) Bottom-Up, and (c) Free-to-Choose, as explained below.

(a) Top-Down mode:

We had 8 subjects in this group. They were given a linear document and asked to divide it into several hypermedia files under the Top-Down mode. In other words, they would read through the linear document, decide the proper size of each knowledge unit, break the linear document into individual files, draw a global structure of the target homepage in the Knowledge Window, and build the links one by one.

(b) Bottom-Up mode:

We had 11 subjects in this group. They were given 34

separate files in the Knowledge Window under the Bottom-Up mode and asked to build up links between the files. The content of the files as a whole was equal to the linear document used in the Top-Down group. In this case, the subjects would read the content of each file, decide the relationship between files, and build the links one by one.

(c) Free-to-Choose mode:

We had 15 subjects in this group. As for the Top-Down group, they were given the linear document. However, they were given the freedom to decide their working mode, Top-Down or Bottom-Up. We wanted to know the preference of the modes when the subjects were given the freedom of choice

IV. Result and Discussion

Among the subjects who were given the freedom to choose the working mode, about 43% of them selected the Bottom-Up mode. We observed the constructed homepage by each subject and defined three quantitative measures to show the difference between experiment groups. The measures are: the Average Depth, the Average Number of Branches, and the Average Number of Terminal Nodes, in the hypermedia homepage. The depth of a node was defined to be the length of the path between that node to the Home node of the homepage. We then took the average value of the depths of the individual nodes to measure the depth of the whole structure. The number of branches of a node was defined to be the number of nodes connected to that node. Again, we took the average value to measure the branching degree of the whole structure. Terminal nodes were those files with no outward connections. We found that these three measures demonstrate important features of the constructed courseware under different modes. We depict the measures in Table 1 and discuss the results in the following.

Table 1. Structure Measures.

	Bottom-Up	Top-Down	Free-to-Choose	
			Bottom-Up(43%)	Top-Down (57%)
Average Depth	3.60	2.57	2.59	2.42
Average Number of Branches	2.l7	0.93	1.7l	0.93
Average Number of Terminals	8.42	22.38	13.2	21.75

(1) Average Depth: From Table 1 we can tell that the average length of paths from the Home node to the content nodes is smaller when the Top-Down mode was chosen. A possible explanation is that because the subjects using the Top-Down mode read the linear document first, so they were largely influenced by the structure implicit in the document. In other words, they first built a hierarchical structure to reflect what they saw in the linear document, then connected the split files. The hierarchical structures are usually shallower than the ones constructed under the Bottom-Up mode in which free association is frequently applied in the building process.

(2) Average Number of Branches: Apparently, this measure is much larger in the Bottom-Up group. Again, we suggest that the linear presentation of the document previewed in the Top-Down group limits the possibility to connect two topics that are distant from each other in the linear document. Furthermore, when a hierarchical plan is developed before hyper-link construction, the author tends to employ only the hierarchical connections and neglects the possible cross-references between nodes in different branches.

(3) Average Number of Terminal Nodes: This measure in the Top-Down group is much larger. Again, this is because when an implicit hierarchy is adopted, nodes at the lowest level become terminal nodes from which no outward links are constructed. In other word, stronger bi-directional reference is resulted when the Bottom-Up mode is chosen.

(4) The values in the Free-to-Choose/Bottom-Up column are between those in the Bottom-Up group and the Top-Down group. We believe this is because after the subjects read a linear document, the implicit structure affects later design, no matter which mode is chosen.

V. Concluding Remarks

From the above observation and discussion, we suggest that the behavior of hyper-link construction reflects the prior knowledge structure of the author. For example, we suggest that previewing a linear document will strongly affect the resulted structure. This hypothesis, of course, needs to be further investigated. Furthermore, not only the constructed

structure, but the construction process also reveals how the author comprehends and organizes the material. We believe this implies a possibility of developing a learning strategy based on hyper-link construction.

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