Supporting Navigation and Learning in Educational Hypermedia

Patricia M. Boechler
University of Alberta, Canada

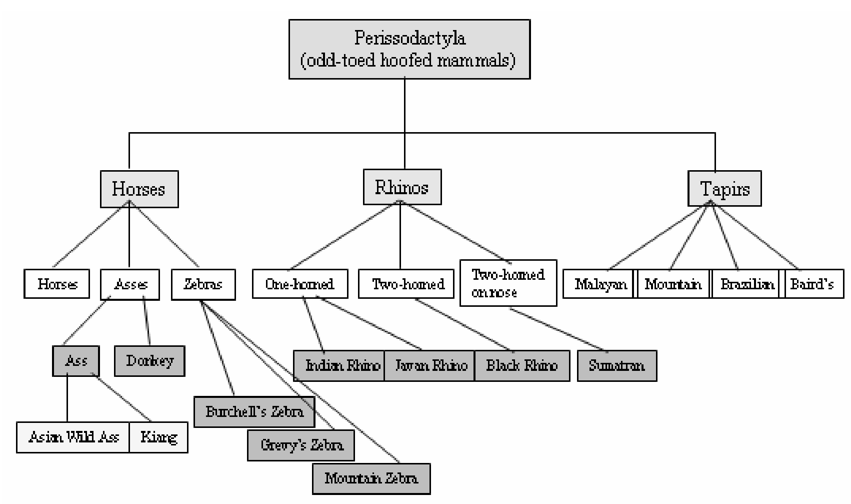
INTRODUCTION

Computers have become commonplace tools in educational environments and are used to provide both basic and supplemental instruction to students on a variety of topics. Searching for information in hypermedia documents, whether on the Web or through individual educational sites, is a common task in learning activities. Previous research has identified a number of variables that impact how students use electronic documents. Individual differences such as learning style or cognitive style (Andris, 1996; Fitzgerald & Semrau, 1998), prior topic knowledge (Ford & Chen, 2000), level of interest (Lawless & Kulikowich, 1998), and gender (Beasley & Vila, 1992) all influence performance. Additionally, characteristics of the document such as the inherent structure of the material, the linking structure (Korthauer & Koubek, 1994), and the types of navigation tools that accompany the document can affect student performance and behaviour (Boechler & Dawson, 2002; McDonald & Stevenson, 1998, 1999). In short, the effective use of hypermedia documents in educational settings depends on complex interactions between individual skills (e.g., spatial and reading skills) and the features of the document itself.

BACKGROUND

Previous research has suggested that one way of addressing ability differences in hypermedia users is to follow a compensatory strategy in which users are provided with mediators, modalities, or organizing structures that make up for a deficit in a particular ability (Messick, 1976). One kind of organizing structure that can help users make sense of material is a spatial structure that illustrates how different parts of the material are related. A spatial map, spatial overview, or graphic organizer is a visual representation of the structure of the document. These are usually in a diagrammatic form such as block diagrams, diagrams organized around a central term (spider map), or hierarchically ordered tree diagrams. For example, see Figure 1.

Figure 1. An example of a hierarchically ordered tree diagram



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Learning depends on the construction of stable and usable mental representations of knowledge. From an educational perspective, how do we induce such representations? When presenting factual (e.g., some apples are red) or demonstrable (e.g., gravity makes things fall downward) information, creating an appropriate mental representation is a matter of relying on these physical aspects of the world to stand as mental representations to be stored, manipulated, or retrieved. The creation of mental representations for abstract and complex ideas is not as straightforward. In the cognitive-psychology literature, it is suggested that people often use spatial structures as metaphors to reason out the relational attributes of a set of abstract elements, attributes that are not observable (Gattis, 2001). Research across several bodies of literature (educational psychology, information science, instructional technology) suggests that the arrangement of visual information in particular in a hypermedia interface can impact both navigation (Allen, 2000; Boechler & Dawson, 2002; Chen, 2000; Westerman & Cribbin, 2000) and learning (Boechler & Shaddock, 2004; Mayer & Sims, 1994; Moreno & Mayer, 1999). In both cases, a successful spatial or visual arrangement should make salient the relations between semantic elements in the document. Concerning navigation, in the information-science literature, Dillon (2000) proposes a spatial and semantic model to explain hypermedia navigation processes. The spatial and semantic model assumes all information spaces convey structural cues that are both spatial and semantic in nature, and that different user characteristics and contexts determine which type of cues will be relied on in relation to one another. Similarly, in the educational-psychology literature, Mayer and Sims propose a dual-coding theory to explain learning in hypermedia. In the dual-coding theory of multimedia learning, learners construct referential connections between the mental representations of the verbal and visual information presented within a hypermedia document. Hence, the underlying assumption is that, for both navigation and learning, the impact of the visual arrangement lies in the degree to which it preserves the meaning relations between different parts of the document material. This mapping of verbal and visual elements can be accomplished using multitudes of diverse visual cues (spatial separation, clustering, bordering, connecting lines, etc.).

THE EFFECTIVENESS OF GRAPHIC ORGANIZERS

Although not all studies support the positive effects of graphic organizers (e.g., Farris, Jones, & Elgin, 2002; Stanton, Taylor, & Tweedie, 1992), in the hypermedia literature, there are many examples of the usefulness of graphic organizers. For instance, Stanny and Salvendy (1995) found that the performance of low-spatial-ability users could be improved to the level of high-spatial-ability users by providing a 2-D (two-dimensional) hierarchical structure as a guide for users. Allen (2000) found that low-spatial-ability users performed better when provided with a word map: a configuration that showed the relationships between words in a bibliographic collection.

McDonald and Stevenson (1999) reported on two studies examining the effects of navigational aids on navigation and learning. The first study indicated that providing a spatial map improved navigation performance over using a content list or no navigation tool. In this case, the map consisted of labels with connecting lines indicating the links between nodes. Navigation performance was measured by task time and the number of extraneous pages accessed. However, this type of spatial map did not improve recall for the document material. The second study showed that providing a spatial map that also included link descriptions that showed the conceptual relations between the pages improved learning.

Boechler and Shaddock (2004) found that the presence of visual links between page labels in a navigation tool predicted incidental learning of material during an information-search task. Whether the navigation tool was two dimensional or three dimensional did not predict these learning outcomes.

Nilsson and Mayer (2002) reported two studies using graphic organizers. They concluded that there are benefits to graphic organizers, but that such benefits come at the expense of other aspects of performance. Specifically, a graphic organizer can assist users in navigation, but if the organizers make

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