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Designing Metacognitive Maps for Web-Based Learning

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ABSTRACT

This paper provides guidelines for designing metacognitive maps in web-based learning environments. A metacognitive map is a visual interface-based tool that supports metacognition throughout the entire learning process. Inspired by the four key metacognitive skills of planning, monitoring, evaluating, and revising, the metacognitive map is composed of two sub-maps (global and local tracking maps) and a planning space for learning processes/tasks. Metacognitive support is embedded within these visual on-screen maps and planning space.

Keywords

Metacognition, Web-Based Learning, Navigational aids, Visual Maps

Introduction

Web-based environments provide new potential to enhance learning through a visual and interactive delivery of instruction. When the Web is employed for instructional delivery, it can provide learners with a variety of diverse internet resources. Without the constraint of time and place, learners can thus search a wealth of relevant information; however, this abundance of rich learning resources can be detrimental for learners who do not possess strong self-regulatory and metacognitive skills to guide their discovery and learning.

Thus, the nonlinear nature of web-based learning environments is often disorienting to learners (Begoray, 1990). According to Tripp & Roby (1990) and Beasley (1994), learners are likely to suffer when disorientation increases. Conklin (1987) defined the disorientation as the tendency to lose the sense of direction and location in non-linear environments. Learning from hypertext requires that learners not only understand the text itself but also browse through the space selectively (Bolter, 2001). Learners must make navigational choices and constantly have to decide which node or link to select next. The navigational decisions that learners need to make while reading from hypertext may present difficulties and impose a higher cognitive load, especially on learners with low prior knowledge (Jacobson *et al.*, 1996). Therefore, one of the important differences in learning from hypertext compared to learning from traditional text is that learners need to understand the *structure* of the information space. It is not a surprise that visual-spatial skills contribute to learning from nonlinear websites (Baylor, 2001), given that understanding how different visually-organized semantic units relate to each other is critical for learners to make better navigational decisions.

Many researchers have studied and proposed methods for reducing disorientation within nonlinear environments. Some of the methods in these studies were concerned with embedding mapping, indices, and providing online guidance (e.g., Allison & Hammond, 1989). Other studies focused on ways to create the website more hierarchically (Jonassen, 1993). Still others considered metacognition when designing web-based learning environments (Lin, 1994). All of these approaches have pros and cons, which were considered in the design of the proposed web-based instructional tool.

The purpose of this paper is to design an instructional tool which can be used to overcome learners' disorientation and enhance their web-based learning experiences. This instructional tool is presented as a *metacognitive map*, including two sub-maps (a global map and a local tracking map) together with a planning space for learning tasks and processes.

Disorientation and Metacognition in Web-Based Learning Environments

In web-based learning environments, learning occurs through navigating information on the web. Sometimes learners experience disorientation in these nonlinear contexts. This type of disorientation is often observed in learning, and can notably limit instructional effects (Collis, 1991; Gay & Mazur, 1989). Specifically, such disorientation can require a longer time for learners to complete their task and distract them in the process.

On the other hand, orientation can be described as the ways by which learners are able to recognize their current position and next direction. Oliver and Herrington (1995) suggest that the orientation can be supported by providing such cues as path trails (or "breadcrumbs") and simple graphics presenting position. It is believed that they can assist learners significantly even though the amounts and spaces of aids to screen presentations are small. Likewise, the metacognitive map proposed here can similarly support learners' orientation within the learning content.

As already mentioned, metacognition depicts learners' cognitive sense of how they understand the given information and what should be done to control or regulate their cognitive processes (Puntambekar, 1995). It is mentioned that there are two important sides of metacognition (Brown, 1987). *Awareness* about cognition and learning is the one of important aspects of metacognition, and the second is *control or regulation* of these cognitive processes. Learners need metacognition when they judge what should be done and where they should go with overcoming perceived shortcomings (Balajthy, 1990).

The levels of metacognition exhibited by the learners were wide ranging. Learners who have a high level of metacognition mainly show several metacognition skills such as flexible planning, continuous monitoring of learning process and thoughtful evaluation of ones' own cognition (Oliver & Herrington, 1995). Also, they can appropriately connect the given task with their own skills or strategies to deal with the task (e.g., Kunz *et al.*, 1992). However, learners who have a low level of metacognition tend to become disoriented in the web-based learning environment. They are likely to forget what they have to do and where they need to go for their next tasks. In this situation, the level of metacognition and disorientation appears to be closely related (Land, 2000; Tabatabai, 2005; Chambers, 1999). Overcoming this disorientation through metacognitive support is thus a primary goal when designing web-based learning environments.

The Underlying Metacognitive Principles of a Metacognitive Map

There are several definitions of metacognition. Flavell (1987) defined metacognition as the ability to understand and monitor one's own thoughts and the assumptions and implications of one's activities. Brown (1987, 1978) described metacognition as the degree to which learners are engaged in thinking about themselves, the nature of learning tasks, and the social contexts. She also described metacognition as being comprised of activities for regulating and monitoring human learning.

According to both Flavell (1979) and Kuhn (2000), metacognition is composed of both metacognitive knowledge and metacognitive regulation. Here, metacognitive knowledge is described as knowledge which is used to manage thinking processes. Besides, the metacognitive knowledge is separated by three parts: knowledge of person variables, task variables, and strategy variables (Flavell, 1979). While Flavell (1987) focused on metacognitive knowledge, Brown (1987) emphasized metacognitive skills or regulations, and defined metacognition as an awareness of one's own cognitive activity; the methods employed to regulate one's own cognitive processes; and a command of how one directs, plans, and monitors cognitive activity. Stated differently, metacognition is made up of active checking, planning, monitoring, testing, revising, evaluating, and thinking about one's cognitive performance (Baker & Brown, 1984). Metacognition begins in an unconscious mode and is followed by increased conscious regulation and self-monitoring in the use of strategies, knowledge, and the acquisition of new knowledge (Brown & DeLoache, 1978). Brown (1987) specifically delineated four components of metacognition: 1) planning, 2) monitoring, and 3) evaluating, and 4) revising. These factors of metacognition are described next.

First, planning refer to the deliberate activities that organize the entire learning process. These planning behaviors consist of establishing the learning goal, learning sequence, learning strategies, and expected learning time. Secondly, monitoring refers to the activities that moderate the current progress of learning. For example , learners can ask themselves questions as follows: "what am I doing," "am I on the right track," "how should I do," "what information is important to complete the given tasks," "should I do with different perspectives," "should I adjust my pace depending on the difficulty," etc. These monitoring activities are conducted typically during the learning activities. Third, evaluating one's own learning processes involves an assessment of the current progress of the activity. This systematic method of evaluation can assist learners with developing the necessary skill sets and strategies from which they can draw in novel situations where it may become applicable. Fourth, revising one's own learning processes involves modifying previous plans regarding goals, strategies, and other learning approaches. In web based learning environments, learners need to be able to create relevant and effective plans that reflect their self awareness of their skills and an understanding of the task requirements. The learners should be self-regulated so that they can monitor their learning process, evaluate their processes by themselves and select appropriate learning strategies to effectively complete assigned tasks through their own metacognition process.

Although metacognition and its constituent elements are defined differently, depending on the researcher, the definition of metacognition as an awareness of one's own cognitive activity is commonly accepted. Also, Brown (1987) places an emphasis on metacognitive skills rather than metacognitive knowledge to improve learning outcomes, because metacognitive skills are more practically employed. The next section describes how these four key metacognitive skills (*Planning*, *Monitoring*, *Evaluating* and *Revising*) are supported through the design of a metacognitive map.

The "Map" aspect of a Metacognitive Map

A map is a generally used navigational aid to reduce learners' disorientation in web-based learning environments; such knowledge-based maps can also be developed by learners as a way to facilitate their understanding of the nonlinear content (Lee *et al.*, 2005). Generally, a map helps learners navigate the learning content by providing a visual structure consisting of nodes and links that represent the learning components and their relationships. Although there are several types of navigational maps (e.g., global map, local map, local tracking map, and fish-eye view), this paper focuses on the use of a global and local tracking map as constituents of a metacognitive map. The global map and local tracking map are classified by the scope of the presentation of the learning content. Specifically, the *Global Map* is used to outline the structure of the entire learning content, and to guide learners to plan their activities more effectively. The *Local Tracking Map* is used to support learners to check what they have already done and to more easily judge what they need to do. Moreover, the *Planning Space* provides a mechanism to support learners' premeditated planning of the learning tasks. In consideration of the potential for learners' cognitive overload, the metacognitive map is devised as an embedded tool within the learning environment. A suggested interface for the metacognitive map is provided in Figure 1 and the functionality of the frames is described in Table 1.

<table>
<tr><td rowspan="3">A. Learning Contents</td><td>B. Global map</td></tr>
<tr><td>C. Local Tracking Map</td></tr>
<tr><td>D. Planning Space</td></tr>
</table>

Figure 1. The Frames of a Metacognitive Map

Next, an interface that applies these principles into the context of "intellectual property" is illustrated and described. As shown in Figure 2, learning content is presented in the left side of interface, while the global map, local tracking map, and planning space are displayed on the right side of the interface. Learners are expected to set their learning goals, learning strategies and expected learning time in the planning space. For example, as their learning goals, they may select "I choose to learn the content of intellectual property based on the four case studies" or 'I will find out the types and characteristics of intellectual property." Also, the learners can set their expected learning time (e.g., 20 or 30 minutes) to complete the current learning goal. Likewise, they can choose their desired learning strategies such as note tasking, mnemonics, diagramming, or compare/contrast of the content.

The overall flow of the system is as follows. If a learner clicks one of nodes on the global map, the content in the left side will show the appropriate content. Whenever learners click a node on the global map, the node will be added and decomposed within the local tracking map. In this way, the global map, local tracking map, and the planning space work together in synergy.

Table 1. Descriptions of Metacognitive Map Components

Components	Description	Metacognitive Support
Learning Contents (A frame)	The current learning content is presented in this frame.	N/A
Global Map (B frame)	The overall structure of the learning content is represented in the form of global map, similar to a site map.	*Planning* The global map facilitates learners in planning their learning from a holistic perspective, facilitating them in planning study time and setting priorities. *Monitoring*

		Learners can monitor their learning processes based on the global map by checking how much they have completed relative to the entire content of the site.
Local Tracking Map (C frame)	Whenever learners click a content area of the global map (B), a new sub-node is generated.	*Monitoring* The local tracking map supports learners to check what they have already completed/learned and to more easily judge what they need to do next. *Evaluating* With the local tracking map, learners can evaluate and think about their performance and how well they have achieved their initial goals. To evaluate their learning, they can refer to their initial plan in the planning space (D).
Planning space (D frame)	This space is for premeditated planning of learning tasks. It consists of three parts; learning goal, learning strategies, and expected learning time. All of these parts are revisable at any time.	*Planning* Learners can check their learning goal, expected learning time, and learning strategies in this space. The global map (B) will be referred to, in support of planning for learning. *Revising* This space can be revised by learners at any time based on their ongoing monitoring and evaluating of their learning. The intent is that learners will adjust their behavior according to the updated plan.

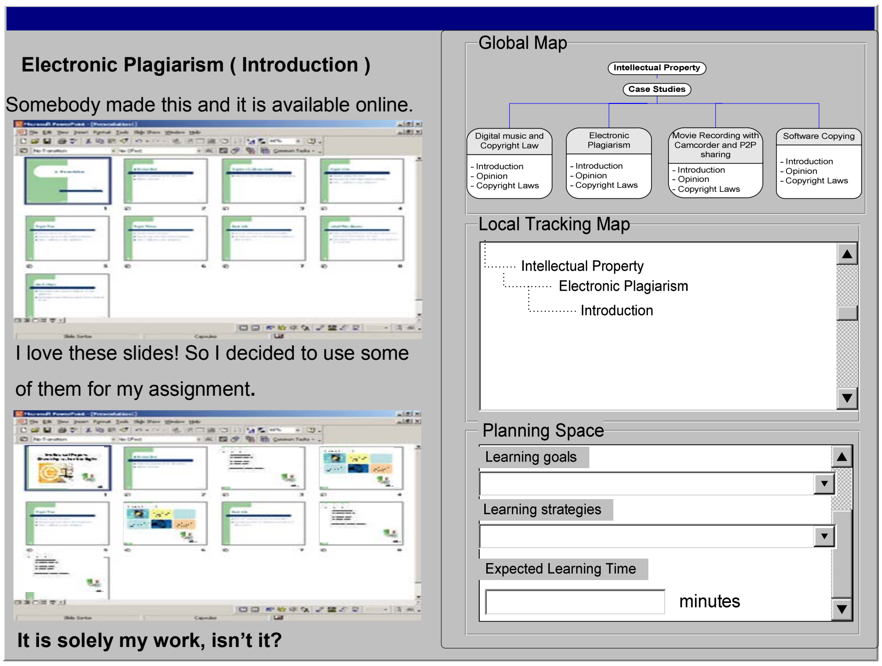

Figure 2. An Example of Metacognitive Map

Conclusions

Inspired by the four key metacognitive skills of planning, monitoring, evaluating, and revising, the metacognitive map is designed as a visual metacognitive support tool. The ultimate goal of this tool is to support learners' metacognitive activities to facilitate their orientation within web-based learning environments. With the metacognitive map, learners are expected to perform both cognitive and metacognitive activities effectively and efficiently. This is supported visually through the maps (global map and local tracking map) and planning space which works in synergy. While the map is theoretically grounded, the next step is to empirically evaluate the effectiveness of this support tool as it impacts metacognition and learning.

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