

Cognitively Informed Multimedia Interface Design

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INTRODUCTION

The rich contributions made in the field of human computer interaction (HCI) have played a pivotal role in shifting the attention of the industry to the interaction between users and computers (Myers, 1998). However, technologies that include hypertext, multimedia, and manipulation of graphical objects were designed and presented to the users without referring to critical findings made in the field of cognitive psychology. These findings allow designers of multimedia educational systems to present knowledge in a fashion that would optimize learning.

BACKGROUND

The long history of human computer interaction (HCI) has witnessed many successes represented in insightful research that finds its way to users' desktops. The field influences the means through which users interact with computers—from the introduction of the mouse (English et al., 1967) and applications for text editing (Meyrowitz & Van Dam, 1982) to comparatively recent areas of research involving multimedia systems (Yahaya & Sharifuddin, 2000).

Learning is an activity that requires different degrees of cognitive processing. HCI research recognized the existence of diversity in learning styles (Holt & Solomon, 1996) and devoted much time and effort toward this goal. However, Ayre and Nafalski (2000) report that the term *learning styles* is not always interpreted the same way and were able to offer two major interpretations. The first group believes that learning styles emerge from personality differences, life experiences, and student learning goals, while the second group believes that it refers to the way students shape their learning

method to accommodate teacher expectations, as when they follow rote learning when teachers expect it.

The first interpretation includes, in part, a form of individual differences but does not explicitly link them to individual cognitive differences, which, in turn, caused researchers more ambiguities as to interpreting the different types of learning styles. In fact, these differences in interpretations caused Stahl (1999) to publish a critique, where he cites five review papers that unite in concluding the lack of sufficient evidence to support the claim that accommodating learning styles helps to improve children's learning when acquiring the skill to read. He criticized Carbo's reading style inventory and Dunn and Dunn's learning inventory because of their reliance on self-report to identify different learning styles of students, which, in turn, results in very low replication reliability.

These criticisms are positive in that they indicate a requirement to base definitions on formal replicable theory. A candidate for this is cognitive learning theory (CLT), which represents the part of cognitive science that focuses on the study of how people learn the information presented to them and how they internally represent the concepts mentally in addition to the cognitive load that is endured during the learning process of the concepts.

Some of the attempts that were made to take advantage of the knowledge gained in the field include Jonassen (1991), van Jooligan (1999), and Ghaoui and Janvier (2004).

Jonassen (1991) advocates the constructivist approach to learning, where students are given several tools to help them perform their computation or externally represent text they are expected to remember. This allows them to focus on the learning task at hand. Jonassen (1991) adopts the assumption originally proposed by Lajoie and Derry (1993) and

Derry (1990) that computers fill the role of cognitive extensions by performing tasks to support basic thinking requirements, such as calculating or holding text in memory, and thus allowed computers to be labeled cognitive tools. Jonassen's (1991) central claim is that these tools are offered to students to lower the cognitive load imposed during the learning process, which, in turn, allows them to learn by experimentation and discovery.

Van Jooligan (1999) takes this concept a step further by proposing an environment that allows students to hypothesize and to pursue the consequences of their hypotheses. He did this through utilizing several windows in the same educational system. The system was composed of two main modules: the first supports the hypothesis formation step by providing menus to guide the process; the second provides a formatted presentation of experiments already tested and their results in a structured manner. They also added intelligent support to the system by providing feedback to students to guide their hypothesis formation approach.

Ghaoui and Janvier (2004) presented a two-part system. The first part identified the various personality types, while the second either had an interactive or non-interactive interface. They report an increase in memory retention from 63.57% to 71.09% that occurred for the students using the interactive interface. They also provided a description of the learning style preferences for the students tested, which exhibited particular trends, but these were not analyzed in detail.

Montgomery (1995) published preliminary results of a study aimed at identifying how multimedia, in particular, can be used to address the needs of various learning styles. Results indicate that active learners appreciate the use of movies and interaction, while sensors benefit from the demonstrations.

Although a glimmer of interest in CLT exists, there is a distinct lack of a clear and organized framework to help guide educational interface designers.

ALIGNMENT MAP FOR MULTIMEDIA INSTRUCTIONAL INTERFACE

The problems that arose with learning styles reveal a need for a more fine-grained isolation of various

cognitive areas that may influence learning. Consequently, an alignment map, as shown in Table 1, may offer some guidelines as to what aspects of the multimedia interface design would benefit from what branch of the theory in order to gain a clearer channel of communication between the designer and the student.

CASE STUDY: DATA STRUCTURES MULTIMEDIA TUTORING SYSTEM

The alignment map presents itself as an excellent basis against which basic design issues of multimedia systems may be considered with the goal of making the best possible decisions.

The multimedia tutoring system considered here (Albalooshi & Alkhalifa, 2002) teaches data structures and was designed by considering the various design issues as dictated by the alignment map that was specifically designed for the project and is shown in Table 1. An analysis of the key points follows:

1. **Amount of Media Offered:** The system presents information through textual and animated presentation only. This is done to avoid cognitive overload caused by redundancy (Jonassen, 1991) that would cause students to find the material more difficult to comprehend.
2. **How the Screen is Partitioned:** The screen grants two-thirds of the width to the animation window that is to the left of the screen, while the verbal description is to the right. Although the language used for the textual description is in English, all students are Arabs, so they are accustomed to finding the text on the right side of the screen, because in Arabic, one starts to write from the right hand side. This design, therefore, targeted this particular pool of students to ensure that both parts of the screen are awarded sufficient attention. It presents an interface that requires divided attention to two screens that complement each other, a factor that, according to Hampson (1989), minimizes interference between the two modes of presentation.
3. **Parallel Delivery of Information:** Redundancy is desired when it exists in two different

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