FROM COGNITIVE LANDSCAPES
TO DIGITAL HYPERSCAPES

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Abstract

The widespread diffusion of e-learning in organizations encouraged the discovery of more effective ways for conveying digital information to learners, for instance, via the so-called LMSs (Learning Management Systems). A problem that we identified is that cognitive variables and pedagogical processes are rarely taken into consideration; sometimes these are confused with the mere use of "diversified" hypermedia resources by learners. Within a context of widespread multimedia content, following the emergence of massive information resources, we discuss the need for more powerful and effective learner-centered tools, capable of handling all kinds of design configurations and learning objects.

Key Terms: cognitive profiles, learning styles, mind mapping, multimedia and hypermedia content, hyperscapes, e-learning, learning objects, Learning Management Systems (LMS).

Introduction

Learner variables are often neglected in the development of educational products and systems. It is quite common to find the emphasis on the multimedia technology itself. Why are cognitive landscapes so faraway when e-learning solutions are applied? In our view, any learning system should address the issue of different individual learning abilities. Indeed, cognitive representations may vary so widely that a single system will not be able to cope with the variation, regardless of the interaction potential it offers (Rogers & Scaife, 1997). Aspects such as learning ability, developmental issues, memory organization and capacity, and the nature of cognitive representation are crucial. Also, there is some evidence (Hay *et al*, 1994) that educational technology affects students differently; it works effectively for some while it fails for others, and the same is true for teachers and tutors. Perhaps these research issues will have to be resolved in the first place, through more in-depth observation and evaluation of subjects that come into contact with e-learning systems.

While researchers might disagree at the frontiers of knowledge about how the human mind works, there seems to be agreement on some basic principles (Kahneman, et al, 1982):

- The mind is an inference machine that actively imposes order on highly ambiguous situations.
- The mind works to keep internal core beliefs consistent and unchallenged (the mind will deny, distort or ignore signals that contradict core beliefs).
- The mind prefers simplicity.
- The mind is constrained by reality in important ways (effect of the circumstances).
- The mind prefers stable and enduring relationships among its core beliefs.

In other words, where nature is ambiguous, people develop strong beliefs and act upon them. Reflective practice and critical thinking also match this strategy. People also tend to simplify complexity and make the inconsistent seem consistent. These are very important factors with strong implications for the design of multimedia and hypermedia learning materials.

Our mental processes make rapid estimates of what is valuable to notice and what can be treated as background - a phenomenon that is extensively addressed by Gestalt Theory. Furthermore, when we look at a composition of images on a screen, the mind takes some of these images and creates something that fits existing mental schemes - we see every image we come across with theory-laden vision. Meanings are assigned differently by each and every one of us.

Cognitive Profiles and Learning Styles

Perhaps because mental schemes are so important for us, and so necessary for orderly interaction with others, people are very reluctant to change them. In fact, people tend to hold on to that self-achieved order and eventually fight to retain their mind maps. Because of this, we argue that in the design of multimedia and hypermedia learning materials the input of individual cognitive preference becomes an important factor.

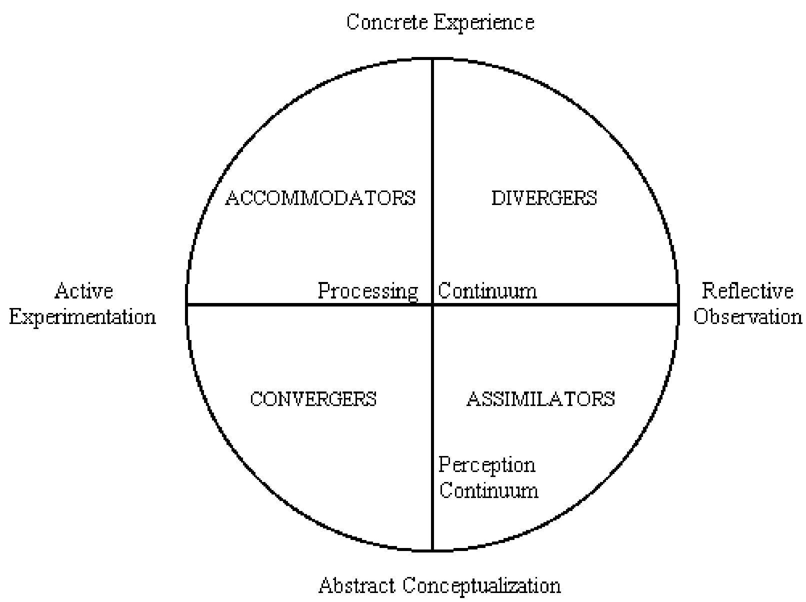
The four types of **cognitive profiles** by Jung (1960) are a first approach, historically situated but worth revisiting:

- **Intuitive** (integrates patterns, possibilities, ideas)
- **Feeler** (main concerns are people and life)
- **Thinker** (focus on cause and effect)
- **Sensor** (concern for activities and events)

Another quadrilogy that we should refer to has been suggested by Uys (1998), based on Kolb’s Model of Experiential Learning (1984). It acknowledges that every student has a mixture of four basic **learning styles**, namely:

- **Reflector**: learning best by reflective observation. Learners can be provided with appropriate exercises in course pages and because a large proportion on the Web is asynchronous it caters naturally for the needs of reflective students.
- **Pragmatist**: learning best by engaging in practical applications. Practical exercises with a problem solving structure and a theoretical support can be implemented having images and sound to contextualize the experience.
- **Theorist**: learning best by abstract conceptualization. As the instructional pages of (information-giving) course material are readily available, the relevant narrative modules can be easily digitized and made available in course pages.
- **Activist**: learning best through activities and concrete experiences. The Web naturally lends itself to "discoveries" through hyperlinks and the main assets are its random navigation possibilities, a high-level of interactivity via e-mail, message boards and chat and, of course, the use of graphics, colors, sounds and movement.

This differentiation suggested by Kolb (1984) stresses the need for a flexible support of these styles, along with the possibility of effortless transition between them, in a group or individual learning environment. The interactions among the relevant factors that make up the profiles are represented by the Model of Experiential Learning:



Kolb's Learning Styles

Cognitive characterizations are also important to define precise design concepts. More specifically we are concerned with the issues designers have to consider in the development of interactive material. The **design concepts** outlined by Rogers & Scaife (1997) seem appropriate and quite relevant:

- **Explicitness and visibility -** how to make more salient certain aspects of a display such as they can be perceived and comprehended appropriately.
- **Cognitive tracing -** what are the best means to allow users to externally manipulate and make marks on different representations.
- **Ease of production -** how easy it is for the user to create different kinds of external representations, e.g. videos and animations.
- **Combinability and modifiability -** how to enable the system and the users to combine hybrid representations, e.g. enabling animations and commentary

to be constructed by the user which could be appended to static representations.

These design concepts can be implemented at a more detailed level by means of technical parameters such as the use of graphics, the kinds of navigation aids or the types of media that can be implemented at the interface. Redundant visual coding could be used to constrain the way information should be interpreted. The coordination of elements and the cueing for certain aspects are also very important. Regrettably, this is often impossible to establish when we use commercial learning management software.

But design considerations cannot just rely on cognitive characterizations. The domain knowledge that needs to be learned has specific didactic characteristics that suggest how we can use different representations. For example, a chronological sequence of historical events may be illustrated by a series of relevant stills (paintings, photos, etc.), a poem may be more adequately illustrated by audio, and a physics experiment could benefit with the playback of slow moving video.

This is also a problematic issue because in many cases the formal representations are not merely explanation aids - they are an essential part of the domain of knowledge itself. So, we must differentiate between multiple representations as a system - by this we mean representation systems such as, for instance, algebra plus graphs - and augmentations of a representational system - for example, using 3D images to show complex data.

The multimedia experience

Although it is desirable that the learner be allowed and encouraged to engage with multimedia and hypermedia materials, in a creative and purposive way, we have to make sure that he has access to a learning experience that both supports and goes beyond what can be achieved with print. To find out how this might be achieved it is necessary to look first at the user interface in a broad perspective in order to distinguish between the mainly ergonomic aspects of access to multimedia materials and the learners subsequent interaction with it. According to Whalley (1997), “the extra resources involved in creating and accessing multimedia materials have to be justified in terms of improved learning, which is unlikely to result from simple issues such as the speed of information access, or to the large quantities of text that can be squeezed on to a CD" (p. 3).

On the other hand, judging from the numerous CD-ROM and Web sites surveyed, a "more is more" philosophy has become very pervasive. Many think that quantity and sophistication of multimedia information are important indicators of the value of educational materials. For example, adjectives such as "eye catching", "mind boggling", "powerful" and "dynamic" are used. From the observation of learners exploring multimedia materials (both on CD-ROM and on the Web) we found out that too much time is wasted wandering about, playing video clips and animations, whilst skimming through accompanying text or static diagrams. A typical example is referred by Rogers & Scaife (1997) concerning the evaluation of a CD-ROM on design (First Person), by Don Norman, where students consistently admitted to ignoring the text in search of clickable icons of the author; the selection of the icon would present an animated video of Don Norman explaining some aspect about design. This did not improve learning as it introduced extra "noise" in the process. Students became quite passive and did not engage in active meaning-making of their own. We can conclude that in reality many multimedia environments may in fact induce more dispersed and superficial learning.

An ideal prototype would possibly have the characteristics of a "microworld" - a learning environment that is highly interactive and geared to open-ended problem solving – possibly relying on modular elements. The environment should be self-contained and provide enough opportunities for multiple views and representations of knowledge. A variety of questions could be posed and the solutions could be explored in constructive ways by means of activities that engage the learner. A natural starting point would be a workstation with a large color screen and a windowing system. The windows divide the screen into logical parts that are used for different purposes. This windows usage is already in the habit of most people. For example, while a browser window shows live video, another window can provide simultaneous text annotation related to the subject. We foresee the need to base any future solutions on robust platforms that support several channels of communication, as well as links between the multiple documents.

Creating digital hyperscapes

The learner's knowledge construction process, following a specific learning profile, should be supported by appropriate multi-channel tools relying on effective hypermedia technology. Hypermedia spaces or hyperscapes may be conceptually identified with huge networks that extend from hypermedia ”pages” to vast knowledge “spaces” on the Web, where the latter tends to grow to a “landscape” dimension. But hyperscapes are also cognitive artifacts that offer expressive power to authors and support active learners in the development of knowledge paths that are relevant to their own aims and needs. As people try to make sense of the fragmentary information that surrounds them they create branched structures of knowledge that depart from a single node; usually there is something that triggers new thoughts, perhaps as a question or a point of view. A key-element in our approach is the explicit introduction of **mind mapping support** in the construction, visualization and navigation of complex knowledge structures (Gaines, 1995). This feature is currently not found in learning content management software.

The construction of hyperscapes may be achieved through Mind Mapping®, a popular technique, invented (and copyrighted) by Tony Buzan in the UK. According to him “*a mind map consists of a central word or concept, around which you draw the 5 to 10 main ideas that relate to that word. You then take each of those child words and again draw the 5 to 10 main ideas that relate to each of those words.*" (Buzan, 1995) Images, graphics and dynamic media elements (audio and video) may be added to this representation. The difference between a concept map and a mind map is that a mind map departs from one main concept, while a concept map may deal with several. Hyperscapes can rely on both kinds of maps, depending on the objectives and strategies we define for a learning environment.

Mapping techniques were developed to represent knowledge in graphs that constitute networks of concepts (Gaines, 1995). Networks consist of nodes (points/vertices) and links (arcs/edges), where nodes represent concepts and links represent the relations between concepts. Concepts and sometimes links are labeled and may be categorized; they can be simply associative, specified or divided in categories such as causal or temporal relations. The developing patterns of association and branching create fractal structures. Like clouds or trees, they form physical structures that do not possess a defined form; in fractal structures we can always describe other levels or scales of its structure where we always find the same basic elements or patterns (*self-similarity*).

Mapping of knowledge is important in modern educational environments because the ultimate goal is the development of reference models that are meaningful organizations of information in the learners mind. Also, learning processes are usually facilitated if we use, for instance, significant sounds, pictures and graphics to express ideas.

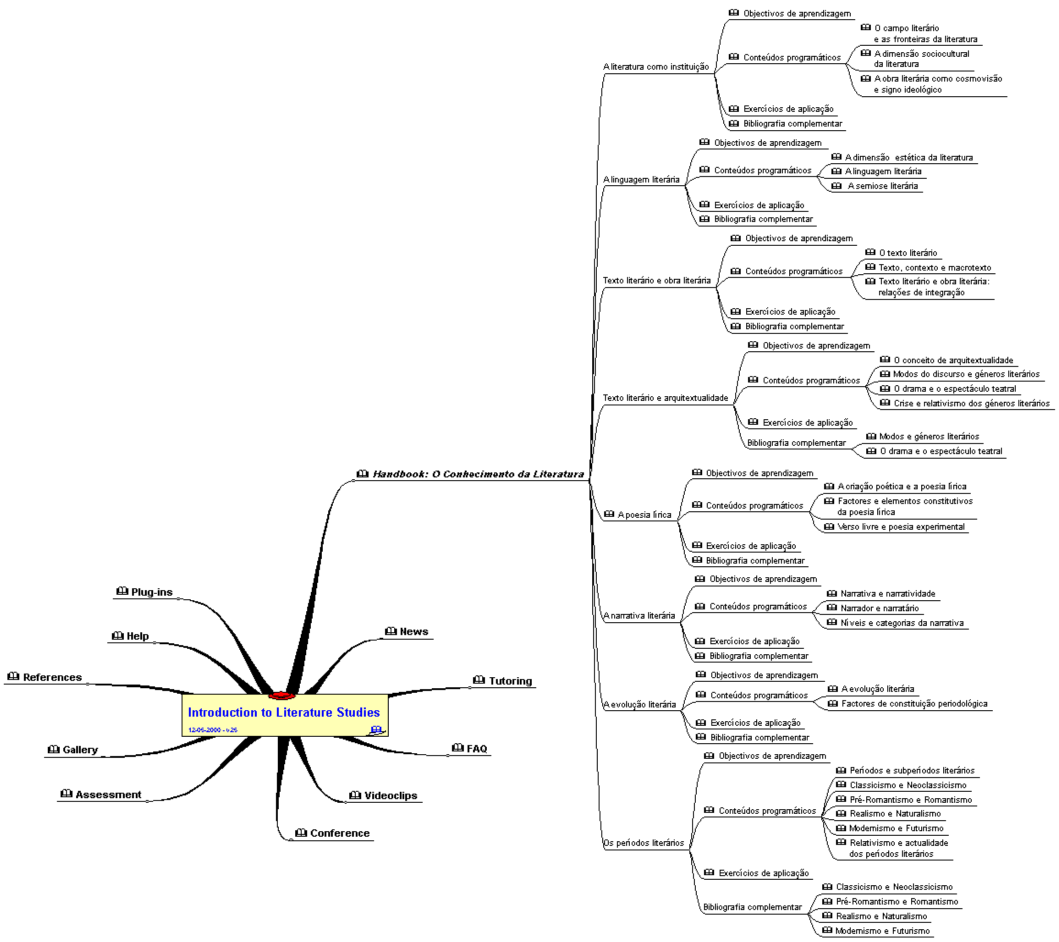
The cognition and learning issues previously discussed justify the need for a framework and a set of requirements to approach multimedia design for educational purposes, namely: (1) flexible access and structuring of knowledge and rich information, (2) flexible interaction with this knowledge and information, and (3) communication and interaction among participants in a learning experience. This framework could be built according to the following design ideas:

- To structure rich information and knowledge, we propose the integrated use of cognitive maps and hypermedia.
- To support individual and collective interaction and manipulation of information and knowledge, we require the ability to navigate and change those structures.
- To enable personal interaction and communication, we require sharing and co-construction of both information and knowledge structures

To support interaction and communication one must take into account the opportunities for interaction, both synchronous and asynchronous, as well as remote or co-located. In this context, the time-space matrix below summarizes the role of the different artefacts.

Interaction	*Same time*	*Different time*
Same space	Enhanced classroom	Shared offline facilities – knowledge and hypermedia structures
Different space	Videoconference and chat	Shared online facilities – knowledge and hypermedia structures

In the past, microworlds have been created to provide an entirely new framework for the learner to explore, but today the Web can already provide plenty of worlds with which to interact. According to Cognitive Flexibility Theory (Spiro & Jengh, 1990), learners are able to spontaneously restructure their knowledge in many ways as they chart their courses through the hypermedia material. For example, they may construct knowledge artifacts initiated by the instructor and further developed and shared in an organic, adaptive and generative manner (Guimarães *et al*, 2000). See knowledge map:



Structure of knowledge map developed with MindManager ™

Technologies that can potentially be used to create learning hyperscapes currently take various forms and tend to have familiar labels, for example: ***E-learning*** for Internet-based learning; ***T-learning*** for Television-based learning; ***M-learning*** for Mobile-based learning. Perhaps these will have a great impact in the near future and change the way we conceive open and distance education.

In a previous experiment (Guimarães *et al*, 2000) a group of students, attending a master's program on Educational Multimedia, was given the task of creating fractal hyperscapes, i.e. mapping and developing of layered Web structures reflecting their interaction with knowledge, and with instructors and colleagues. The aim was to find out how the learning process evolved with students working together as architects of conceptual hyperspaces. The emphasis was put on the levels of engagement and motivation attained and the final quality of the hyperscapes material. Students were given a basic conceptual map with the main themes of the course, which they had to explore and develop further, both offline and online. They were encouraged to proceed from (non-linear) thinking to (non-linear) authoring of hyperscapes in a process with four phases: preparation, construction, interaction and presentation. Final assessment was based on project work following standard academic procedures. Results turned out to be very promising but faculty effort was overpowering (both authoring and tutoring).

Learning Management Systems

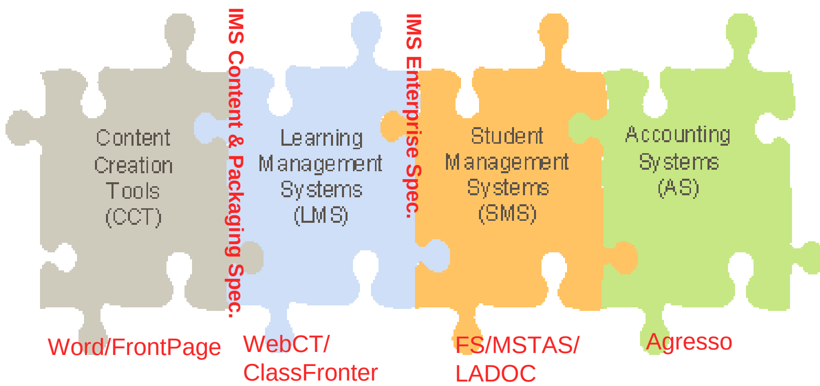
If we look at the corporate world of today we find many learning web sites organized around tightly focused topics, which contain specific technologies (ranging from chat rooms to groupware) that enable users to submit and retrieve information in a mechanical manner. In these environments we find reusable “objects”, media-independent collections of information used as modular building blocks for e-learning content. These combinations of technologies and learning methodologies usually take the form of software and/or hardware products that suppliers tout as answers to businesses' training needs. In general, these emergent technologies do not provide the tools we need to create learning hyperscapes – not in the sense we have discussed so far. However, these technologies try to solve some interesting “engineering” problems…

The current e-learning systems are based on a group of innovative software solutions in which we include the Learning Management Systems (LMSs).

Paulsen (2002) describes four main categories of systems:

- Content Creation Tools (CCT)

- Learning Management System (LMS)
- Student Management System (SMS)
- Accounting System (AS)



(*in* Paulsen, 2002, p. 23-24)

The LMSs try to cover a range of pedagogical and technical issues, for instance: learning and design theory, hardware and software purchase, students support services, student's assessment, student's interaction, instructional strategies, security and firewalls, staffing. The goal of this type of platform is to enable an information system that can handle online, students, teachers, courses, and course material.

Paulsen (2002) states that an online college may have to handle thousands of students, hundreds of teachers, and a large number of courses with password restricted web pages, discussion forums, distribution lists, class rosters, and student presentations. It may also have to provide administrative systems for the dispatch of textbooks, handling of tuition and examination fees, and organization of local examinations. Institutions that plan to offer large scale and professional online education need an administrative system, which is integrated with the Web. In this technological context it becomes clear that the main issues still to be addressed are associated with the instructional design enabled by the system, the expectations and specific needs of the learners, and the role of the teacher in this new environment.

Learning Objects

Today's tendency to develop large-scale e-learning systems, often including proprietary learning methods, creates the need for stabilized processes, based on learning objects, specifications, requirements and standards. The ideas of content portability, granularity and interoperability often complete the notion of systems compliant with certain norms, allowing users to migrate easily from one system or software to another of the same kind.

It's striking that terms like *standards*, *requirements*, *specifications* and *learning objects*, currently used in e-learning, are all engineering words. The problem is that what these terms represent becomes part of an "engineering process" rather than being part of a "pedagogical process". Pedagogy theories seem to be positioned faraway in another domain of knowledge. Surely, this dependency on technology and software development is driving e-learning research into new grounds, but with what effects?

An important aspect of e-learning is that it depends upon digital technology for implementation. New and improved information technologies like databases, Learning Management Systems (LMS), Learning Content Management Systems (LCMS), search engines, etc. are giving new possibilities for storing, retrieving and reusing information objects across systems, time and geography. In Singh's White Paper "*Demystifying eLearning Standards"* he explains these as:

> "**Content portability -** When content has been separated from proprietary delivery systems, the organization can consolidate, organize and track their e-Learning initiatives in the LMS of their choice. Because this is true for both third-party custom content, corporations will have greater flexibility and lower switching costs.
>
> **Granularity -** The new specifications supports the learning object methodology, allowing for smaller and more timely units of information. Learning objects adds "just enough" to "just-in-time" learning.
>
> **Interoperability** - Application interoperability starts where different e-Learning applications can share content and tracking data. But even more exciting, these

> specifications open up the possibility for different types of applications to swap and access content." (Olsen, 2002, p.160)

Learning objects are seen as units of information that one can manipulate and operate with. This way content should be organized according to a structured framework, in such a way that each "information piece" is an independent unit, which can be defined by metadata. This idea enlarges possibilities for reusing, assembling and manipulating learning units and (re)organize them according to specific needs.

According to Olsen (2002), the fundamental idea behind this model (object oriented design model) is that content can be split up and put back together in new learning tracks/courses in the same way you play with blocks of LEGO™. Recent research (Koper, 2001), aimed at building a semantic notation for complete units of study in e-learning, shows that a unit of study (or learning object) can not be broken down to its components without losing its semantic and pragmatic meaning or attain the proposed learning objectives. So, these units of study may take the set form of a course, a study program, a workshop, a tutorial or any kind of lesson.

Unfortunately, these models always put the focus on learning with bits and pieces of information (=objects) and forget the didactic or pedagogical model behind it. Learning perspectives that take into consideration cognitive variables or that are situated within the learners sphere of interests must be taken into account.

Conclusion

Within a context of widespread multimedia content, following the emergence of massive information resources, we discussed the need for more powerful and effective learner-centered tools, capable of handling all kinds of design configurations and learning objects. But how do we really address the major needs of learners using new information technologies like databases, Learning Management Systems, Learning Content Management Systems?

A first recommendation is to consider a model sustaining the acceptance of information technology by the learner, namely, find out:

- What users want the e-learning system to look like and what functionality should be included (e.g. cover different learning styles);

- The degree to which an individual believes that using a particular e-learning system would enhance his or her global performance (e.g. show cost/benefit);

- The amount of mental or physical effort an individual has to put in to take any benefit from the e-learning system (e.g. develop straightforward tutorials)

Secondly, the construction of knowledge is also a problem of self-development, based on an evolutionary process, often with a rather unpredictable outcome. Implicit suggestions are: to adopt pro-active learning strategies, to foster the collaboration with peers and other students, to adopt a bold perspective concerning the problems to solve. For instance, “chaotic” elements that enter the processes in creative activities (e.g. generation of ideas) have to be managed according to each learner’s path and progression to arrive at a final result that is valid.

This extra flexibility does not mean that a less professional approach is applied but that a great deal of the “authority” usually attributed to the teacher or the organization is not desirable today. Nevertheless, looking at the latest learning platforms, we find that these cognitive variables and pedagogical processes are rarely taken into consideration; sometimes they are confused with the mere use of “diversified” hypermedia resources by learners. What's left is the idea that pedagogy vs. technology is a problematic contest that needs yet to be clarified by further research. We don’t know for sure how learning may take place in the realm of today’s Web hyperscapes and digital technologies. But we know a great deal about the human cognition workings.

In conclusion, we looked through some emerging issues in e-learning, covering both old and new conceptual spaces, tried to establish a bridge between cognitive issues and digital technology solutions, described new ways for instructional designers to create materials, and showed how to engage learners in reflective practice and critical thinking with mind mapping. Much more needs to be done, but perhaps Gavriel Salomon pointed the way ahead when he said: “Let technology show us what **can** be done, and let educational considerations determine what **will** be done in actuality” (keynote, Ed-Media 2000).

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