Plant a Tree in Cyberspace: Metaphor and Analogy as Design Elements in Web-Based Learning Environments

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ABSTRACT

Analogy and metaphor are figurative forms of communication that help people integrate new information with prior knowledge to facilitate comprehension and appropriate inferences. The novelty and versatility of the Web place cognitive burdens on learners that can be overcome through the use of analogies and metaphors. This paper explores three uses of figurative communication as design elements in Web-based learning environments, and provides empirical illustrations of each. First, extended analogies can be used as the basis of cover stories that create an analogy between the learner’s position and a hypothetical situation. The Dragonfly Web pages make extensive use of analogous cover stories in the design of interactive decision-making games. Feedback from visitors, patterns of usage, and external reviews provide evidence of effectiveness. A second approach is visual analogies based on the principles of ecological psychology. An empirical example suggests that visual analogies are most effective when there is a one-to-one correspondence between the base and visual target analogs. The use of learner-generated analogies is a third approach. Data from an offline study with undergraduate science students are presented indicating that generating analogies are associated with significant improvements in the ability to place events in natural history on a timeline. It is concluded that cyberspace itself might form the basis of the next guiding metaphor of mind.

INTRODUCTION

The World Wide Web is opening new horizons for improving the mind. Today nearly 40% of college courses list Web resources in their syllabi, and more than a quarter of college courses have their own Web page. It has been estimated that by 2002, 2.2 million college students will be enrolled in distance-learning courses, up from 710,000 in 1998. Already the vast majority of college students in the United States are linked in cyberspace, with 50% having Internet access from their residence halls. As the technology continues to advance at an astonishing rate new techniques are coming online every month. Tools such as Java and CGIs are being augmented by audio/video streaming and new hybrid technologies such as Shared Hypermedia. However, precisely because of its rapid development, it is easy for students and teachers to lose their bearings in cyberspace. Well-constructed analogies and metaphors can make the difference between a meaningful learning experience and an exercise in confusion.

In thinking about the potential of the Web as a learning environment, it may be useful to start with a comparison to the textbook. The ba-
sic structure of the textbook—straightforward expository writing organized by chapters, with topic headings and subheadings—was established long ago. Before a student first “cracks” a textbook (on any topic) he or she will have a pretty good idea of what to expect from the format. One can now write better or worse textbooks, but the nature of the textbook itself is no longer open for negotiation. This is not the case for Web-based learning environments. The basic structure of Web-based courses and Web-based learning resources is still evolving (indeed, the learning environments we create today will shape that evolution, and help set the standard for tomorrow). The structure of the textbook may stifle creativity and produce boredom in students, yet for all its deficiencies the textbook is an efficient way of transmitting information. Part of its efficiency stems from the set of expectations students have about textbooks. For example, the use of chapters, headings, and subheadings contribute to norms for studying. Techniques such as the SQ3R study method (Survey, Question, Read, Recite, Review) are designed to capitalize on these regularities of textbooks. Such norms for rigorous study have not been developed on the Web. Indeed, recent research suggests that only 16% of users actually do a word for word reading of the text on Web pages. This is hardly a norm well-suited to education. Learners need structural and rhetorical devices that help them use their world knowledge to make sense of novel situations. Analogies and metaphors are precisely this kind of rhetorical device. Just as the Macintosh and Windows operating systems capitalize on the desktop analogy, designers of Web-based learning environments can use analogies and metaphors to help students learn. In this paper we will consider three different uses of analogies and metaphors as design elements in Web-based learning environments, and examine the evidence from three empirical examples.

WHY ANALOGIES AND METAPHORS?

Analogies and metaphors are two kinds of figurative speech people use to help make sense of unfamiliar conditions by drawing upon knowledge domains that are better understood. A metaphor is a figure of speech in which one or more characteristics of a base are implicitly transferred to a target. For example, the phrase “the autumn of his life” transfers the qualities “late season” and “graceful decline” from the fall season to a person’s lifespan. An analogy is a figure of speech where one or more relationships among characteristics of a base are transferred to a target. For example, in drawing an analogy between stimulating a nation’s economy and “priming the pump,” it is the relationship between the application of water and the subsequent smooth function of a pump that forms the basis of the analogy. Just as pouring a little water into a pump sometimes helps it function efficiently to bring forth a great deal of water, so too, as the analogy goes, relatively modest government investments in a nation’s economy can provide the impetus for much economic growth. It is worth noting that, unlike metaphors, neither the qualities of “water” or “pump” are of particular importance. Rather, it is the relational structure that is transferred from base to target.

Although there are important differences between the major psychological theories of analogy, the field is close to consensus on the broad outlines of analogical reasoning. Gentner and Holyoak note that all current theories of analogical reasoning address some aspects of this basic process:

One or more relevant analogs stored in memory must be accessed. A familiar analog must be mapped to the target analog to identify systematic correspondences between the two, thereby aligning the corresponding parts of each analog. The resulting mapping allows analogical inferences to be made about the target analog, thus creating new knowledge to fill gaps in understanding. These inferences need to be evaluated and possibly adapted to fit the unique requirements of the target. Finally, in the aftermath of analogical reasoning, learning can result in the addition of new instances to memory, and new understandings of old instances and schemas that allow them to be better accessed in the future. (p. 33)

Much of the generative power of metaphoric and analogical reasoning lies in the ability to
make inferences about new situations based on knowledge derived from cognitive mapping. In the case of metaphors, attributes or characteristics are mapped from base to target. In the case of analogies, relationships among attributes are mapped. Of course, analogies can be more or less metaphoric, and similar processes are presumably involved in mapping abstractions to particular instances.

Metaphors seem to play a special role in human memory and cognition. There is evidence that memory for metaphors is sometimes independent of memory for literal text. Reyna found that participants in a memory experiment “were able to recognize the exact wording of metaphors, and to reject highly similar distracters, even after a delay of 12 days” (p. 55). Harris et al. found that memory for metaphors was consistently better than memory for similes, and that unlike other kinds of discourse, the addition of meaningful contexts only slightly improved memory for the most difficult sentences. In short, metaphors and analogies are powerful rhetorical devices, and our cognitive architecture seems particularly well tuned to exploit them in maintaining an understanding of the world.

THREE USES OF METAPHOR AND ANALOGY

We have seen that the Web can be used to provide powerful and yet unfamiliar learning environments for students, and that metaphors and analogies are effective devices for helping students make sense of unfamiliar situations. In this section, we will briefly consider three uses of metaphor and analogy in the development of Web-based learning environments. In the following section we will explore empirical illustrations of these approaches. First, analogy and metaphor can be used as the basis of “cover stories” that provide context for interactive experiences. Cover stories can be used to guide interactions with the computer, and provide a plausible rationale for technical limitations. Second, visual analogies can be used to capitalize on the goal-directed nature of the human perceptual system. Principles of ecological psychology have been successfully applied to dynamic and interactive diagrams and other visual displays. Finally, we will consider the potential for directing learners to develop their own analogies online. Recent evidence suggests that the act of generating analogies, as distinct from hearing or reading analogies created by others, is a particularly powerful method of learning.

The analogous cover story

An important use of figurative communication is to create a meaningful context for interactive experiences through the use of a hypothetical cover story. Such narratives serve to guide the learner’s interactions. For example, consider a learning experience in the domain of political science dealing with the U.S. Presidency. A standard textbook approach might be to provide historical examples or political principles in the form of expository text, and perhaps provide some study questions at the end of each chapter. Those same materials could form the basis of interactive experiences where learners read very brief passages and engage in interactive decision-making games that require them to make use of newly acquired knowledge. A learner might play the role of U.S. President in a hypothetical situation, and make policy decisions, respond to world events, try to get legislation through congress, and improve his or her standings in the polls with an eye toward re-election. Of course, the player would in fact be doing none of these things. He or she would really be interacting with a Web page by reading text and clicking on buttons. However by creating an analogy between the Web-based learning environment, and the actions of the President of the United States, we are able to provide context and meaning for an experience that might be technologically similar to a multiple-choice quiz.

Of course, someone playing the role of President of the United States might very well wish to create government policy, rather than choose from predetermined options. Unfortunately, it would not be possible to anticipate every policy every visitor to a Web site might develop. A good strategy for limiting options would be to embellish the cover story to account for these limitations. Perhaps the story might indicate
that the President is a former Vice President who was thrust into office following the resignation of the former President. Perhaps she is politically weak, and presides over an uneasy coalition government. Thus, according to the cover story, she must choose among alternative policies suggested by a set of cabinet officers (or campaign contributors) because she is not yet politically strong enough to dictate policy. The President must weigh how these options will be treated by various constituencies, and choose how to best achieve her goals in a particular political context. Such a cover story explains the narrow range of options in plausible way, and permits detailed feedback about how others would respond to various policy options.

The use of an analogous cover story creates a meaningful context and can have a dramatic impact on the visitor’s experience. Figurative communication such as analogies and metaphors can be used to turn the basic structure of a multiple-choice quiz into an engaging interactive game. As Wolfe notes, “careful attention to context may serve the designer by steering the visitor toward an appropriate set of alternative actions, provide opportunities for useful and appropriate feedback, and hide technical and practical limitations” (p. 109).

**Visual analogies**

People are dynamic visual information processors. We are highly efficient movement detectors, and sensitive to subtle changes in the visual field. Unfortunately, more often than not, there are discrepancies between the human perceptual system and the way learning materials are presented to students. Traditional media, such as textbooks, are capable of presenting only static visual displays, whereas the Web is well suited to presenting dynamic displays. Research in ecological psychology indicates that perception is guided by patterns of information in the environment. Gibson’s Theory of Affordances suggests that organisms use these patterns of information to direct actions based on perceived opportunities afforded by the environment. Affordances are constrained by the goals, knowledge, and skills of the perceiver, as well as inherent characteristics of the perceptual environment. Of course, Web designers control many aspects of the perceptual environment of a Web-based learning environment. Ecological psychology suggests that visual analogies are a powerful technique that takes advantage of the nature of the perceptual system. The basic concept of a visual analogy is that relationships should lawfully map onto relevant facets of the environment.

People are able to handle large quantities of complex information efficiently when complex relationships clearly map onto the perceptual environment. For example, users of a computer network might benefit by seeing a continually updated dynamic display of a pipeline representing the amount and kind of traffic on the network. Different colors might be used to designate different kinds of activity such as sending E-mail, surfing the Web, and downloading MP3 files. Volume of traffic might correspond directly to areas on the screen, with a theoretical maximum corresponding to a visual display of a “full pipe.” Principles of ecological psychology suggest that people are well equipped to readily interpret such displays. Universities sharing these visual analogies with all users might find more support from students for policies restricting the use of their networks for accessing MP3 files (assuming that such uses do, in fact, account for an unacceptably high volume of traffic). The creators of Web sites should deliberately design such lawful relationships into their visual displays.

**Generating analogies online**

The third use of metaphor and analogy as design elements in Web-based learning environments is to have learners generate their own analogies online. The basic concept is to invite learners to construct their own analogies, rather than receiving analogies provided by an instructor. There are strong indications that student-generated analogies significantly impact certain kinds of learning. For example, in the domain of science education Wong found that self-generated analogies led participants to construct new explanations and ask important questions about scientific concepts. Just as learners are finely tuned to subtle changes in visual analogies, and are able to re-
call subtle metaphors with great accuracy, the act of generating analogies seems to produce lasting conceptual changes in learners.

There are a variety of techniques that can be used online to encourage learners to generate effective and appropriate analogies. First, students might be invited to post instructional analogies to a Web site to be used and critiqued by other students. Sherman found that learning was significantly facilitated when advanced social psychology students created Web-based lessons for use in an introductory social psychology course. Second, students might be invited to create visual analogs of complex concepts to demonstrate their understanding of intricate interrelationships. For example, one could design a Web site where learners are able to assemble visual elements into a functional whole. People visiting the site might be invited to create a visual analogy demonstrating the principles underlying a suspension bridge. Visitors would succeed only when they assembled the elements in a viable configuration. Finally, the technique of using a cover story might be used to encourage the creation of learner-generated analogies. For example, visitors might be told that they need to explain the functioning of a suspension bridge to someone from a very remote village who understands how a stone arch works, but knows little else about the modern world. The analogies could be posted to the Web with CGI forms for evaluation by teachers and other learners.

**EMPIRICAL ILLUSTRATIONS**

Three uses of figurative communication in the creation of Web-based learning environments were briefly laid out above with some hypothetical examples. Next we will consider three instructional uses of metaphor and analogy, and the empirical evidence of their effectiveness. First we will examine the effectiveness of the analogous cover story on the Dragonfly Web pages. Second, we will explore the use of visual analogies in teaching hemodynamics. Finally, we will consider the consequences of generating analogies in comprehending geologic time.

The analogous cover story

The Dragonfly Web pages make extensive use of interactive decision-making games that are aided by the use of analogous cover stories. The Dragonfly Web pages are located at http://www.muohio.edu/dragonfly/ and have been on the Web since March 25, 1996. As of this writing, the Dragonfly Web pages have received over 425,000 visits to the main Dragonfly home page, with the rate of visitation increasing over time. The Dragonfly Web pages consist of nearly 400 interlinked pages. Today, over 400 people visit the main home page each day, or about 12,500 per month. The BBC (British Broadcasting Corporation) Education Web Guide (http://www.bbc.co.uk/webguide/) states that they are “particularly impressed by the quality and educational content.” The pages were awarded the Digital Dozen award for “outstanding math and science Internet sites” from the Eisenhower National Clearinghouse for Science and Mathematics. Web This Week awarded the Dragonfly Web Pages 4 stars on August 30, 1999, and they were honored as a USA Today “Hot Site of the Day.”

The interactive decision-making games on the Dragonfly Web pages are “bitesized” experiences, generally taking less than 10 minutes to complete. These experiences are game-like in that the visitor is placed in a fanciful situation and given a goal via an analogous cover story. To achieve these goals, the visitor must make decisions about how to apply what they are learning. Each of these games distills key points from brief text passages to create choice points. Generally, visitors are put in a fanciful situation, sometimes even “playing God,” as when designing a snowflake. For example, the Trees edition of the Dragonfly Web page invites participants to plant a tree in cyberspace. Visitors are first presented with introductory text describing some of the factors associated with differences in the shape of trees. Participants are given an analogous cover story asking them to create a tree ideally suited to a coniferous forest in Alaska, a temperate forest in Ohio, and a tropical rain forest. Children “design” a tree to adapt to each environment. In the first round, children are instructed to design a tree to grow in the understory of a tem-
perate forest. They choose between tree heights of 8 or 33 meters; flat, round, or conical branch design; and broad leaves or pine needles. After the child "designs" a tree for a particular environment, he or she will see a picture of the tree, along with specific feedback about its chances of survival. In the case of a suboptimal response, the child may try again, or move on to another environment. After designing trees for three environments, the child is given a field exercise on the Fibonacci number series and plant geometry.

It is well established that context has demonstrable effects on learning and instruction. These interactive decision-making games provide meaningful contexts for applying what is being learned through the judicious use of analogies. By striving to achieve goals in meaningful contexts, visitors think through the relationships among key variables, such as the shape of a tree and its ability to compete for sunlight.

An index to the difficulty of these interactive decision-making games is the pattern of usage across various options. Each decision can be thought of as a pathway, and the terminal point of those pathways are unique Web pages containing specific feedback tailored to a constellation of responses. Data collected by Wolfe et al. suggest that most games are neither too easy nor too difficult for the population that visits the Dragonfly Web pages. A majority of visitors choose the best pathway at each decision point, but relatively few are able to put together the best constellation of decisions.

Wolfe et al. found evidence of effectiveness from analyzing usage statistics, unsolicited reviews from unbiased experts, an observational study of children interacting with the Dragonfly Web pages, and feedback from visitors. "Of the 237 visitors who made evaluative statements, 218 (92%) made positive evaluations, and 19 (8%) made negative evaluations. The most frequently used adjectives used to describe the Dragonfly Web Pages were 'Great' (77 messages), 'Good' (42 messages), 'Like' (37 messages), and 'Cool' (39 messages)." Wolfe et al. concluded that that the Dragonfly Web pages are well liked and well respected, and that many visitors enjoyed their visits, and stated that they provided a rich learning experience.

**Visual analogies**

An empirical example of visual analogies comes from research by Effken and colleagues. They developed a program to teach nursing students the underlying principles of hemodynamics (blood flow in the body), and the effects of various drugs on hemodynamics. They used three different visual displays to present the same information in different ways: a strip chart display, an integrated balloon display, and a moving square display. The strip chart display presented information as discrete bar graphs. The integrated balloon display showed how the physical connectivity of the cardiovascular system constrains the values that pressure and blood flow take at each point in the system. The moving square display showed how pressure and flow are constrained by the underlying factors of resistance, heart strength, and blood volume. Students used the displays to learn scientific principles and integrate the information to arrive at a correct diagnosis.

Effken and her colleagues found that found that each enhancement of the display resulted in faster and more accurate problem solutions by students. Students learned to solve simulated clinical problems very quickly with the moving square display, because there was a direct visual analogy between visual symmetry and diagnosis. Any break in symmetry indicated a problem. Students found it more difficult to diagnose using the other two displays because the relationship between drugs and the clinical problems was a one-to-many relationship. However, these researchers found that the balloon display was the best tool for teaching principles of hemodynamics, and suggested two reasons for this finding. First, the balloon display contained more of the semantic context of the clinical situation. Second, the balloon display required that students actively explore the display to discover the relationships between pressure and flow, and the drugs they must use to control them.

Effken et al. asked participants to list the 'best' and 'worst' things about the display, and
to list the steps they used to correct the last problem encountered so that someone else could solve the problem easily. All but one of the participants who worked with the balloon display, addressed pressures and flow explicitly. In contrast, none of the participants using the moving square display addressed pressures or flow in their descriptions.\textsuperscript{16} They concluded that the strength of the moving square display was its support for detecting and treating hemodynamic problems quickly. However, the features that made it effective for this purpose made it less effective for teaching underlying principles. It appears that working with each type of display produced a different conceptualization of hemodynamics and problem treatment. Thus, Effken et al.\textsuperscript{15,16} concluded that the difference in mental representation was due to two design aspects: the level of analysis at which the problem was described—which relationships and constraints were emphasized by visual analogies—and the way the semantics of the problem mapped onto the display geometry. The moving square display changed the nature of the problem and allowed the participants to ignore difficult questions about how drugs relate to pressures and blood flow. Essentially, the moving square display made it possible to solve the problems without fully considering the variations in pressures and flow. Thus, diagnosis was swift, but participants did not need to learn difficult underlying principles.

This empirical example suggests that visual analogies can have a powerful effect on learning and the mental representation of problems. However, the different kinds of visual analogies can produce dramatically different results. Displays that take advantage of our ability to perceive symmetry, and set up a direct one-to-one correspondence between relationships in the base and target analogs, are the easiest to use. However, such displays can sometimes “do the thinking for the learner,” precluding the necessity of learning more difficult relationships for themselves.

\textit{Learner-generated analogies}

An empirical example of the consequences of encouraging learners to generate their own analogies comes from an offline study in the domain of natural history. The goal of this study was to investigate the consequences of generating analogies about the age of the earth, and some important events in its history. To assess participants’ mental representation of geologic time, they were given a time line with the two end points labeled “Earth’s Crust Forms” and “Today.” Participants were given a list of events such as “life first appears,” and “first mammals appear,” and asked to place them on the time line in the appropriate location. Next they were given a chronology of geologic events and asked to develop an analogy between geologic time and a familiar quantity, such as a calendar year. Participants were 81 first-year undergraduate students enrolled in two successive interdisciplinary natural science courses at a university in the Midwest.

A pretest—intervention—7-month delay—post-test design was employed where generating analogies was the intervention. The goals were to assess the diversity of analogies participants generated, and examine the consequences of generating analogies after an interval of 7 months. The pretest was administered in the first interdisciplinary natural science course immediately before the analogy task was given. On the Time Line task, the position of marks was measured to the nearest millimeter. Accuracy was measured in millimeters by the absolute distances between the participants marks ($M$), and the position of marks in correct proportion to the geologic time chronology ($C$) as $|M - C|$. Total accuracy was measured as the sum of the distances between participants marks and correct marks as $\Sigma |M - C|$, with a perfect score being 0, and average accuracy is reported as $\Sigma |M - C| / 14$ items. The result was a single score per participant representing mean distance from target in mm.

Participants produced a range of geologic time analogies, and most were idiosyncratic. For example, one participant made an analogy between the age of the earth and the distance from New York to the north end zone in Chicago’s Soldiers Field. In this analogy, one would be 30 yards from the end zone (“within field goal range”) before the first humans appeared. Others mapped geologic time to pages in a book, musical notes, and even the Satur-
day morning cartoon line-up. To assess the persistence of effects, creating the analogies and the post-test were separated by over 7 months, at which time the Time Line task was again administered in the second interdisciplinary natural science course. On a per-item basis, participants were “off the mark” by a mean of 79.7 mm (SD = 38.67) in the pretest, and 63.5 mm (SD = 15.25) in the posttest. Posttest performance was significantly more accurate, $F(1,62) = 5.86, p < 0.02$.

Seven months after generating the analogies, participants were asked to “reflect upon what you’ve learned about natural history.” Post hoc analyses reveal two general themes in the participants’ written responses: a strong affective response, and a belief that it was a learning experience. Consistent with an appropriate gist representation of geologic time, many participants reported a feeling of awe at the limits of their own lives in relation to geologic time. Comments such as “I realized how small we are,” and “makes you feel a little insignificant in relation to the big picture” were common. One participant wrote:

I was thinking about the earth and how hard it is for me to comprehend 1000 years, yet the earth is over four billion years old. And when I thought about how long ago life appeared on Earth, I had no idea how small we seem today in comparison. The extensive amount of time over which the Earth has grown just blows my mind. I chose to scale all this time down into the stairs I walk everyday, so I could think about all these years of events every time I used the stairs.

Comments such as “helped me understand,” and “gave me a deeper insight” illustrate the belief expressed by many that generating analogies was a significant personal learning experience.

This study suggests that generating analogies can have a powerful effect on learning. Participants in this offline study were significantly more accurate in placing events on a time line after generating their own analogies than beforehand. Moreover, the participants themselves reported that this was a powerful learning experience. As previously discussed, there are a number of techniques for incorporating this approach into Web-based learning environments, allowing learners to share their analogies with their instructors and one another.

**CONCLUSIONS**

Analogy and metaphor play a special role in human cognition. They provide a memorable means of integrating new information with prior knowledge to produce deeper comprehension and creative inferences. Over two decades of solid basic empirical research have led to a well-grounded understanding of analogical reasoning that can form the basis of effective instructional analogies. Relative to traditional teaching tools such as textbooks, the novelty and versatility of the Web place additional cognitive burdens on learners. These burdens can be eased, and the interactive nature of the Web can be used to fuller effect, through the use of carefully crafted analogies and metaphors.

This paper explores three uses of analogy and metaphor as design elements in Web-based learning environments, and provides empirical illustrations of each. First, extended analogies and metaphors can be used as the basis of analogous cover stories. These cover stories create an analogy between the learner’s position and an analogous factual or fictitious situation. The Dragonfly Web pages make extensive use of analogous cover stories in the design of interactive decision-making games. Feedback from visitors, patterns of usage, and external reviews provide evidence of effectiveness. Visual analogies based on the principles of ecological psychology are a second powerful use of analogy as a design element. An empirical example provided by Effken et al.\textsuperscript{15,16} suggests that visual analogies are most effective when there is a one-to-one correspondence between the base and visual target analogs. However, different kinds of visual analogies have different consequences for teaching principles and promoting effective diagnosis. Learner-generated analogies represents a third approach. Data from an offline study with undergraduate science students indicate that generating analogies in the domain of natural
history is associated with significant improve-
ments in the ability to place events on a time
line, an effect that was robust over a 7-month
interval.

We have seen that Web-based learning envi-
ronments may be significantly enhanced by meta-
phors and analogies. Wiley and Schooler,17 in
turn, argue that cyberspace itself is likely to be-
come the predominant metaphor for mind for
the next generation of psychologists. They ar-
gue that for both the mind and the Web, so-
plicated search engines sort through large
networks of information to provide associa-
tions that are most relevant to the task at hand.
Just as people choose which Web sites to sub-
sequently click on, so too do we navigate men-
tal space. Like lists of links from a search en-
gine, multiple ideas often come to mind and we
decide which idea to pursue. The Web analogy
also illustrates the relationship between con-
scious and unconscious processes. When we
search our minds, we decide which topics to
consider, and when alternatives come to mind
we can choose between them. However, we
have relatively little insight into the specific
search processes that bring particular thoughts
to mind. Similarly, on the Web we choose our
search terms, but we can not control what spe-
cific links will be listed by a search engine.

Wiley and Schooler17 suggest a number of
important implications of the mind—Web anal-
ogy. First, it indicates that understanding how
to navigate through cyberspace may provide
us with a rich set of metaphors for conceptual-
izing human information processing. More-
over, they argue, the parallels between the Web
and the mind may actually influence the man-
ner in which individuals learn to retrieve in-
formation from memory. Surfing the Web in-
trouces a variety of demands for optimal
searching. One needs to know how to conduct
a search appropriately, and how to assess the
relative merits of alternatives. These skills
might also apply to searching memory, sug-
gesting that some of the information-searching
skills acquired through surfing the Net might
ultimately become generalized and internal-
ized. Experiences in cyberspace may result in
improving the mind by helping people define
problem searches, and conceptualizing hyper-
linked representations. In short, the cyberspace
analogy may provide an intuitive model of the
mind that can serve to increase our under-
standing and improve mental performance.

Analogies and metaphors allow us utilize
world knowledge to help with novel situa-
tions. Cyberspace is perhaps the most ubiqui-
tous and important novel situation facing hu-
manity today. Thus, analogies and metaphors
have an important role to play in cyberspace.
Every age has had a guiding metaphor of the
mind. Historic examples range from the hy-
draulic moving statues described by Descartes
to the digital computer analogy that still holds
sway in some quarters. If Wiley and Schooler17
are correct, then cyberspace may form the next
guiding metaphor of mind. Just as analogies can
help implant the Web in the mind, so too, cyberspace may become the
analogous basis for discovering the mind in the
Web.

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