

## COGNITIVE AND EDUCATIONAL IMPLICATIONS OF VISUALLY RICH MEDIA: IMAGES AND IMAGINATION

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As images and animations become easier to use within electronic texts, the nature of “written communication” is changing. A fundamental question, as such communications can no longer be assumed to be composed primarily of words, is, how does this evolution in the nature of written communication change the transmission of knowledge? Surely images are a powerful means of presentation, allowing for vivid and indelible experiences on the part of the reader, and in some cases a picture may be worth a thousand words. However, although under some conditions images may allow for an immediate apprehension of a new concept, research in cognitive science has demonstrated that in other cases, images and animations may actually lead to poorer understanding and distract the reader from understanding the central message of a text. In an age in which visual forms of presentation are becoming more and more prevalent, it is important for authors and educators to recognize the potential cognitive implications of including graphics, pictures, or animations alongside, or instead of, prose.

In the past, Arthur Glenberg and Mark McDaniel (1985), among other cognitive researchers, have argued whether text alone can be an adequate surrogate for experience. A related question is whether visuals can be an adequate surrogate for educational text. An important aspect of text and the way a text conveys information is its structure. Although in some ways the structure of a linear text confines a reader to a set path, it is also a very powerful tool for communication, as it leads a reader through inferences and elaborations to the conclusions of an argument only after important and relevant evidence or premises have been advanced. Well-written educational text guides the reader to new understanding, not just through the transmission of information, but through allowing the reader to build a conceptual model of the subject matter. To what extent can images change this relationship with text? This chapter will examine the educational implications of visual adjuncts and how they may affect the processing of conceptual information and therefore, the transmittal of knowledge within particular

subject matter areas. In short, this chapter will examine advantages that can be obtained from including images in text (as adjuncts to the textual presentation of information), but it will also note a number of conditions that constrain what kinds of images are useful and how they should be presented. Further, instances in which presenting visuals can interfere in the relationship with text and actually prevent readers from developing understanding will also be investigated.

Specifically, evidence from studies in cognitive science will be brought to bear on the question: How does the ability to embed images and animations into multimedia webs of information affect our ability to convey information that has been traditionally transmitted via written text? Note that the emphasis in this chapter will be on cognitive processes that underlie and relate to understanding: the comprehension of a text, conceptual memory for the new information, and the ability to use new information in decision making and problem solving. The first part of this chapter will give the reader a background in studies that have shown the cognitive benefits and costs of using multimedia presentation in relation to learning in specific subject matter areas. The latter part of the chapter discusses when and how images and text should be presented to maximize the benefits and minimize the potential cognitive costs of visually rich presentation.

### **What Are the Benefits of Visually Rich Presentation?**

One thing that visually rich presentation surely provides for the student is an image. And images have several advantages over text. First, as Diane Schallert (1980) found, students prefer images or texts with images (whether pictures, graphics, or animations); readers will choose illustrated text over plain text most of the time. Images, especially animated images and virtual simulations, can make the learning experience closer to real-world experience, and as a consequence the experience can be more vivid and more engaging for the learner as has been demonstrated by Meredith Bricken and Chris Byrne (1993) and the work of Christopher Dede and his colleagues (Dede 1995; Dede et al. 1999). Further, K. Ann Renninger, Suzanne Hidi, and Andreas Krapp (1992) have found that readers are more interested in illustrated text and tend to spend more time on readings in which they are interested, which has been shown to improve learning in some cases.

Bernd Weidenmann (1989) makes the important point that the way that we process images is different than the way we process text. Whereas reading text requires readers to fixate on every word or two, for around 300 milliseconds a word, going from left to right and from the top line to the bottom line, images are scanned much more

quickly and globally. Processing of images is much more “holistic,” as people generally assume that a cursory scan across an image is sufficient for them to process the content of the image. Thus, people may feel that images are easier to process and require less effort than words do. There is some evidence (for example, in Larkin and Simon 1987) that more information can be considered at once in graphic form and that it is easier to shift one’s attention among different parts of an image than among different features mentioned in text. Thus, there is some support for the idea that image-related processing is less effortful. Although scanning a picture takes less effort than reading, however, several studies by Susan Palmiter and Jay Elkerton (1983), and Stephen Payne, Louise Chesworth and Elaine Hill (1992) have found that it also generally yields only superficial processing of information. Conditions that lead to better comprehension tend to require effort, including refixations and deep thought about features and relations, whether in an image or an animation or in a text. Similarly, although images may be more attractive, in that they are more pleasing, they are also more distracting, in that they attract attention even when the reader would be better off engaged in deep thought or reading. Beyond these limitations, which will be discussed in more detail later in the chapter, there are some very robust reasons why image-based presentation can sometimes be a quite effective way to convey new information.

One example of when images are beneficial is situations in which deep processing of all presented information is simply not possible, especially when there is a massive amount of information that is available, as in the case of information streams from space stations or weather satellites. As Lloyd Rieber (1995) suggests, in cases when the amount of information to be processed is overwhelmingly huge and from many possible dimensions, the simplification provided by converting the multi-dimensional data into a dynamic visual representation may be the only way to get a handle on the incoming stream of data. Some studies suggest that images provide a more efficient way of presenting multiple dimensions and the relationships between those dimensions than text (e.g., McDaniel and Waddill 1994), and Dede et al. (1999) note that this may be the case especially to the extent that designers use preattentive cues such as color and motion to direct the viewers’ attention to relevant features of the image.

Another possible advantage of visually rich presentation is that it may allow for information to be represented in memory in multiple ways. Alan Paivio’s dual-coding theory (Paivio 1986; Clark and Paivio 1991) suggests that there are two forms in which information can be represented in our memories. One of these forms is predominantly verbal, and the other is visuospatial. A great deal of previous research within cognitive

psychology has suggested that, to the extent that information can be coded redundantly (that is, in both verbal and visual form), we are more likely to remember that information. Presenting images along with text can improve our memory for the concepts that are presented, as we will have dual traces (or two forms) of memory for the ideas mentioned in the text. Thus, to the extent that images allow for multiple forms of representation in memory, visually rich presentation may improve our memory (that is, our recall) of text.

On another level, images may improve our comprehension of text. In many cases the ability to visualize a situation is related to our understanding of the information that has been presented. “Seeing” the path of Stephen Daedalus through Dublin or the circular chain of actions that corresponds to photosynthesis and the Krebs cycle means that we have achieved a certain level of comprehension in reading from James Joyce or a high school biology text. Cognitive psychologists, including Deirdre Gentner and Albert Stevens (1983), have referred to this ability to visualize a process as a “runnable mental model.” Further, it would seem that an expedient way of enabling a student to visualize the process of photosynthesis and to attain a mental model of the process would be to show him or her a visual simulation or animation of the process.

Similar to this concept of a mental model, Walter Kintsch’s (1998) construction integration model posits that readers build a similar structure, a situation model, as they try to comprehend text. In the cognitive literature, it is assumed that as readers process text, they attempt to represent it in their memory. One form of representation is relatively close to direct perceptual experience and can be seen as a “surface” model. In the case of reading text, the exact words that were used would be a part of this surface model. On the other hand, as a reader attempts to understand the meaning of the input, she develops a situation model, which is an abstraction of the text. The situation model includes the gist or meaning of the new input, integrates the new information with information in memory, and represents the reader’s causal or conceptual understanding of the subject matter. In many cases, whether it is a representation of the action sequences in a novel or an understanding of how photosynthesis works, this model can be image based. In such cases, situation models and mental models would be quite similar, and as Wolfgang Schnotz, Justus Bockheler, and Harriet Grzondziel (1999) suggest, it is easy to see how a simulation or image would directly facilitate the creation of such a model. Even when the understanding of the subject matter does not necessarily require an image-based representation, however, an image can still facilitate the creation of a situation model if it provides the basis for an abstract model of the content of the text. Hence, figures, graphs, or flowcharts that may enable the reader to think about abstract concepts through images may allow for the creation of more

complete situation models and as a consequence may in fact improve comprehension of text, as the studies of Darrell Butler (1993) and William Winn (1988) have demonstrated.

Finally, it is possible that in some cases, images alone without text may be the best way to promote understanding of some concepts and attack some problems. Work in verbal overshadowing by Jonathan Schooler, Stellan Ohlsson, and Kevin Brooks (1993) has shown that in some cases images can be overpowered by text or labels. Perhaps the best example is in insight problem solving, in which representing a problem verbally sometimes limits the discovery of possible solutions. Anecdotes of discovery are rife with examples in which imagery played an important role; for example, Amit Subhash Kulkarni's discovery of the benzene ring is said to have been inspired by a vision of a snake chasing its tail. Here the experience in a visual space in which the problem solver can manipulate the problem without the limitations of language is thought to contribute to true discovery. A second arena in which the image may be superior to language are situations in which experts from two different fields are attempting to collaborate on a problem. Marek Kohn (1994) notes that using an image to convey a problem can help experts without a common vocabulary talk across disciplines. It is unclear how much of everyday learning may be able to take place in such a linguistic vacuum, but there may be instances in which an image needs to stand alone, so that each viewer of the image is free to develop an understanding on his own terms, whether using his own vocabulary or in a nonverbal way. Particular domains—those in which information is inherently spatial or complex—may lend themselves to visual presentation of information. Similarly, work by Timothy Hays (1996) on individual differences in learner preferences suggests that some learners may require images to attain an understanding of subject matter, whereas other students may prefer a more verbal mode of communication. All of these factors will affect a particular student's ability to learn from visually rich presentations.

### **When Visually Rich Presentation Fails**

With all these potential benefits of images, it is perhaps surprising that for the past forty years, the empirical results of studies on learning from text with visual adjuncts have been less than positive. In an early review of studies using illustrated texts, S. Jay Samuels (1970) found little support for the superiority of illustrated text over plain text. In fact, in some cases, Samuels found, illustration leads to poorer learning than simple text presentation. Follow-up investigations suggest that one reason for the lack of a consistent positive effect of images on learning is that any learning effect depends

greatly on the kind of image that is used. In a review by Joel Levin, Gary Anglin, and Russell Carney (1987) that discriminated between decorative illustrations and representative, organizing, and interpretive images, decorative illustrations, not surprisingly, were found to lead to the smallest improvements in, and sometimes even to negative effects on, learning. Decorative illustrations are often not relevant for the important concept that is conveyed by the text, yet they are still interesting for the reader and will attract the reader's attention. For this reason, emotionally interesting but irrelevant pictures can be seen as part of a larger class of "seductive-details" effects that have been studied by Ruth Garner, Mark Gillingham, and Stephen White (1989) and Shannon Harp and Richard Mayer (1998). Seductive details are elements of a text that do not support a main point but to which readers choose to devote a large portion of their attention. Photographs containing interesting scenes and pictures of people are often emotionally interesting. Yet, especially in the understanding of science text, Harp and Mayer found that they generally distract the reader, focusing her on irrelevant prior knowledge, thus leading to poorer understanding of the content. Similarly, Anne Treisman and G. Gelade (1980) suggest that color and motion are preattentive cues that necessarily attract a reader's focus. If they are not used to emphasize conceptually important information, they too can seduce the reader. Thus, conceptually irrelevant visuals do not help communication, and in some ways may impede it.

A second caveat for using visually rich presentation is that even when images are relevant for understanding the target concept, there is a danger that images or animations may make knowledge acquisition too easy or effortless. Weidenmann (1989) notes that people tend to feel that a short glimpse of an image is generally sufficient for understanding. This can lead to an illusion that they understand a graphic or image and that they have absorbed all the information that is available in it even when they have not really engaged in deep thought about the information. On a second level, sometimes an image, especially an animation, can provide so much information so easily that readers will have a good idea of how a dynamic system works (for example, they may know what the process of photosynthesis looks like in action) but they may fail to develop a good understanding of why the system works the way it does (so that they could re-create the system or apply their knowledge to a new instance, as has been shown in Palmiter and Elkerton 1983 and Payne, Chesworth, and Hill 1992). It may be that such understanding can come only from having to read text and imagine the dynamic system themselves. Although in such cases the visualizations are in fact communicating the descriptive information quite effectively, students may not actually be

learning to the same extent as they would if they were able and compelled to generate the visualization themselves. This effect has in fact been demonstrated in studies by Linda Gambrell and Paula Jawitz (1993), and Schnotz, Bockheler, and Grzondziel (1999), in which the act of imagining leads to better learning than when the complete mental models are provided for students. In a number of instances, still pictures or still sequences of pictures, from which readers need to infer movement for themselves, have led to better understanding of dynamic systems than animations that actually show the motions (e.g., Hegarty et al. 1999). Further, the studies by Palmiter and Elkerton and Payne, Chesworth, and Hill suggest that this active construction of a runnable mental model is especially important for long-term learning.

Of course this “constructivist” approach is limited by several variables, such as the reader’s level of knowledge and ability. Readers can use their imagination to visualize a scene only when they know what to imagine, so images that provide readers with the basis of a mental model and animations that show the dynamics of a model may be especially important for people who lack such knowledge. The goal in instruction is to find a match between readers’ knowledge and the amount of visualization that they can accomplish on their own, so that they can engage in a maximal amount of active processing of information, with a reasonable probability that they will be creating a correct mental model of the subject matter. The bottom line is that in some respects the goal of educational text is not simply the transmission of information, but the production of appropriate mental representations of the information on the part of the learner. The goal of the learner is not necessarily acquiring a correct descriptive visualization of the phenomenon being explored, but the construction of a correct conceptual or causal explanatory model, which may require some effort on the part of the learner.

One might ask whether there is a parallel in aesthetic experience. Simply having a “mental model” of the path that a novel’s main character takes through a town does not really give us the experience of the main character. Instead, reading about the character’s path through the town conjures up particular feelings and insights and gives us a sense of immersion in the episode as we experience the revelations and epiphanies of the characters. Although any reader may know from the Cliff’s Notes version where the main character ends up and how he got there, there is a sense of intimacy and intensity that comes from re-creating the novel in one’s own mind’s eye. Similarly in learning, true understanding may not be in knowing the end state of a problem, but in the experience of constructing an explanatory construct that leads one to the answer.

A final aspect of images that affects their communicativeness, especially within educational texts, is the extent to which they are realistic images versus symbolic or

abstract illustrations. Although images that are highly realistic may be easier to process, and perhaps more engaging, they are less likely to convey conceptual knowledge to the viewer. Animations that are reproductions of real-world actions are more effective if they are “doctored” to emphasize important features of the display (e.g., Faraday and Sutcliffe 1997). For instance, Mary Hegarty et al. (1999) found that animations with labels, arrows, or narrations that emphasize important features, relations, and movements lead to better learning outcomes than animations that are merely real-time simulations. And, Hari Narayanan and Hegarty (1998) found that animations that are stoppable and restartable under the learner’s control may lead to better learning than real-time simulations. Similarly, images that represent systems can use either representations that are very faithful to real life or more abstracted representations. For instance, Judith Effken, Namgyoon Kim, and Robert Shaw (1997), investigated the effects of image type on a lesson on the circulatory system. Students saw either images of a human heart and blood vessels or a schematic model of the circulatory system. The schematic abstraction may require more effort to process, but the effort is directly relevant to representing important relations and elements in memory. Hence, building on the principle that active processing of information is better, especially when students are forced to construct their own mental model of the information, it would follow that abstract models may be more helpful in acquiring an understanding of the circulatory system than more real-life images. In Effken, Kim, and Shaw’s study, the schematic diagram supported better decision making and understanding of the consequences of drugs on the circulatory system than the more realistic display. Again, individual differences among learners will affect whether and the degree to which symbolic representations enhance learning, and perhaps only students of higher ability will be able to benefit from symbolic representations, as the process of “unpacking” a diagram or figure may impose a load on processing. To the extent that students can handle the extra demands, however, images with more symbolic representations seem to focus their attention on conceptually important features, which can result in better understanding.

Based on the empirical studies discussed above, it seems that visuals that are faithful to real-world experiences in many ways are not as beneficial for learning as more abstract and incomplete sources of visual information. In short, including images in text can have advantages, but there are also a number of conditions that constrain what kinds of images are useful and how they should be presented. There are also instances in which presenting visuals can interfere in the relationship with text and actually prevent readers from developing understanding.

## When and How to Use Visual Adjuncts

In a series of studies, I have been examining which conditions lead to the best understanding from electronic multimedia. So, for example, I have manipulated features of Web sites such as the placement and kind of overview that readers may get, as well as the number of windows they are given in which to read documents. In general, the design of my Web experiments is to have students read through a Web site at their own pace. The purpose of reading through the documents is usually to write an opinion-based essay on a topic such as “What caused the significant change in Ireland’s population between 1846 and 1850?” or “What caused the explosion of Mt. St. Helens?” or “What impact did the building of Grand Coulee Dam have on Washington state?” Following the writing of the essay, students are presented with several questions to assess their understanding of the material they have read. Included in the test questions are some factual recall items, as well as items that require conceptual understanding or inferences based on the presented material. Learning is assessed by examining both the essays that students write and their performance on the posttests as well. As a result, the effects of different kinds of presentation of information can be assessed.

The first principle of effective visual presentation that I have been investigating is minimizing the possibility of images’ acting as seductive details. There are two ways of achieving this goal: minimizing the possibility of competition between picture and text and ensuring that the pictures used are relevant to the material presented. In relation to the first alternative, if one chooses to use certain pictures or images whose chief attraction to viewers is their emotional interest, they should be presented in a way that does not compete with text, for example, on a separate page in a Web site. In line with this theory, in one experiment students were presented with photographs showing the aftereffects of earthquakes (e.g., collapsed bridges and cars sticking out of ditches) either at the same time as a text about the causes of earthquakes (in the same document, as on a standard textbook page), or immediately before the text, or in hyperlinks from the text in which the pictures were presented in their own window.

When pictures were presented at the same time as the text, there was a clear seductive-details effect; that is, students were less likely to develop an understanding of what causes earthquakes when they had pictures embedded in the text than were students who read plain text. When students had access to the photographs through a link, they also showed a seduction effect and learned as little from the text as the embedded-pictures group had. Students who received the emotionally interesting pictures beforehand, however—and could not return to them while they were reading text—did

not show a seduction effect. They had the same amount of learning as students with no pictures but rated the task as more interesting. This suggests that even emotionally interesting images can be used to pique interest in scientific subject matter, as long as they are presented in a way that does not directly detract from the amount of time spent reading a text containing conceptual information. Patricia Wright, Robert Milroy, and Ann Lickorish (1999) and Rieber (1992) found similar results when they looked at learning from animated graphics. Students learned better from animated graphics when they were presented separately from text.

A further twist on the use of evocative images in text is that in some domains, emotionally interesting pictures, for instance, photographs of people, may not be just seductive details. In particular, history teachers often use primary sources such as photographs to prompt students to think about specific historical contexts. It is possible that in such contexts, emotionally interesting adjuncts such as photographs may improve rather than detract from comprehension. Following this intuition, in the same study described above, a second experiment used historical subject matter (based on a Web site about Columbia River history). As in the study using texts about earthquakes, students were presented with either plain text, text with links to images, or text with images embedded in the text pages. Whereas emotionally interesting photographs embedded in text seemed to distract readers from the scientific text on earthquakes, the embedded photographs and images on the history site made readers of the history text more interested, led to more time spent on the reading task, and improved understanding on tests of the subject matter following the reading phase.

There may be many factors underlying this difference in learning from illustrated text in history and science. One possible explanation is that the texts were not matched for difficulty, and it is possible that the concepts in the science texts were more difficult, and thus more vulnerable to competition from the images. A second possible explanation is that in order to understand how earthquakes happen, readers may need to create a visual model, and the presence of irrelevant pictures may have directly interfered with the visual processing required to create such a model. On the other hand, understanding how Native Americans were displaced and the effects of the Grand Coulee Dam on the Columbia River region may not have required any visual processing, in which case understanding was not in competition with the presented images. A third possibility is that emotionally interesting photographs of people do motivate readers to learn more about the people they see, which may in fact prompt them to develop a better understanding of the historical context. For whichever reason, it is interesting that a seductive-details effect was avoided and the “emotional” images did not have negative effects on learning from historical text.

As noted earlier, the second way that one may avoid seduction effects is simply to make sure that the images that are presented are relevant for the concepts to be learned. In this way, any time that is spent viewing a particular image should actually be helping the reader to better understand the concepts that are presented in the text. A corollary to this principle is that images will be especially communicative to the extent that they highlight important conceptual relations and emphasize key features either through salience or symbolism. Similarly, images may be particularly helpful toward learning when they have structure that makes important conceptual relations obvious or when they provide organization for new knowledge, especially knowledge that is abstract.

Another principle of visually rich presentation is that when one wants readers to learn from a text, it is best to present them with just enough information to enable them to construct and imagine their own visualizations of the text. That said, there are individual differences in spatial ability and visualization skill that make images and animations more important for understanding for some readers. In one study of individual differences, Hays (1996) found that readers with low spatial ability achieved a better understanding of the chemical principle of diffusion after viewing an animation, but other studies have shown that students who have good visualization skill are generally better off generating their own visualization of dynamic processes from still pictures.

Finally, when subject matter is complex and dynamic, such as that involving interpreting streams of data from weather satellites or space stations, or just difficult to visualize, then visuals and animations may help people understand the subject matter regardless of ability. For example, Vicki Williamson and Michael Abraham (1995) found that animations helped students understand the particulate nature of matter, a concept from chemistry of which it is difficult for students to form an accurate image. Similarly, visual representations of complex data can give human thinkers the ability to consider many more dimensions, and the salient relationships between those dimensions, than they might otherwise.

The fact that images are most effective toward communication when they are conceptually relevant may seem obvious, but open almost any textbook and you will find scores of images that serve purely decorative purposes. In fact, in a recent survey of publications, Butler (1993) found an increase in the percentage of pictures included in text but *not* in the percentage of data representations or conceptual graphics. Thus, as electronic publishing makes visually rich presentation even easier, the trend toward inclusion of greater numbers of decorative images may continue and seep into new media. In particular, the capacity of the CD has encouraged a “kitchen sink” approach to instructional support: Load up any of the CD-ROMs that publishers are now includ-

ing with textbooks and look at the wide range of images that are available and the range of relevance they have to the subject matter of the textbooks they accompany. Although such image collections may lend themselves to romantic notions of enabling limitless and unconfined creative exploration, just as with hypertext, effective knowledge acquisition usually requires structure, coherence, and relevance. Browsing and surfing through images may allow the viewer to make some novel associations, but we must remember that “chance favors the prepared mind” and for most students, a battery of images of varying degrees of relevance will only overwhelm them and obscure any lesson that is intended to be learned from the images.

The thrill that one anticipates when one envisions the facilitation of new connections in students’ minds through exposure to imagery is a siren’s call to inclusion of more images in the student experience, but extensive gains in this area are not realistic in everyday practice. We must remember that there is also a “joy of discovery” that comes from reading carefully crafted text and epiphanies that a reader may experience that are engineered by the author. Although imposing a linear structure or limiting the presentation of images to specific windows of opportunity necessarily reduces the chances of remote, novel, or random discoveries that a reader might make, on the other hand, it supports a larger number of smaller inferences that will support a better, more basic understanding of the topic in most readers. This is one reason why a return to a pictorial age seems unlikely in education. The construction of an argument that guides the student through evidence to a new conclusion or conceptual understanding is still perhaps the most reliable means for transmitting subject matter knowledge. Visual adjuncts can serve an important role in clarifying and providing vivid examples of evidence and in exciting the reader about a topic, perhaps even in providing an aesthetic or persuasive experience, but the images and animations themselves can hardly stand alone in terms of subject matter learning.

Perhaps the most striking evidence for this conclusion are recent results from experiments with virtual reality. Virtual reality, in which the viewer has direct experience with images, is the ultimate visualization tool. Here, the “reader” is now an “experimenter,” and the potential exists to convey an understanding of new concepts through direct experience. Yet in a review of the literature on virtual reality, Joshua Hemmerich and I found that virtual reality experiences are not easily translated into learning experiences, and the results of studies on the educational uses of virtual reality underscore the same principles as have been discussed in this chapter with respect to the use of other visual forms (Wiley and Hemmerich forthcoming). The bottom line is that students do not learn by the simple transmission of information. Virtual reality adds value

to educational contexts when it goes beyond “realistic” experiences in ways that make elements important for conceptual understanding obvious, while leaving some work in constructing a coherent representation up to the student.

The way that information is transmitted can have a significant influence on understanding, and any change in the modal form of communication is sure to have an impact on educational practice. Just because a dynamic image-based representation and the ability to visualize a particular scene or process is a desired end state, however, does not mean that a visually rich presentation with great fidelity to the real-world situation is going to be the best medium for educational communication. At least at this point, what we can conclude from the evidence in the cognitive literature is that students need structure and emphasis on important elements to develop understanding, whether they are learning from text or images. That said, images can play an important role in supporting written texts, as well as making them more memorable and vivid for the reader, as long as they are conceptually relevant, and as long as something is still left to the imagination.

### Acknowledgments

The preparation of this chapter was supported by grants to the author from the Paul G. Allen Virtual Education Foundation and the Office of Naval Research, Cognitive and Neural Science and Technology Program. The opinions expressed in this chapter should not be taken to reflect the positions of these organizations.

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