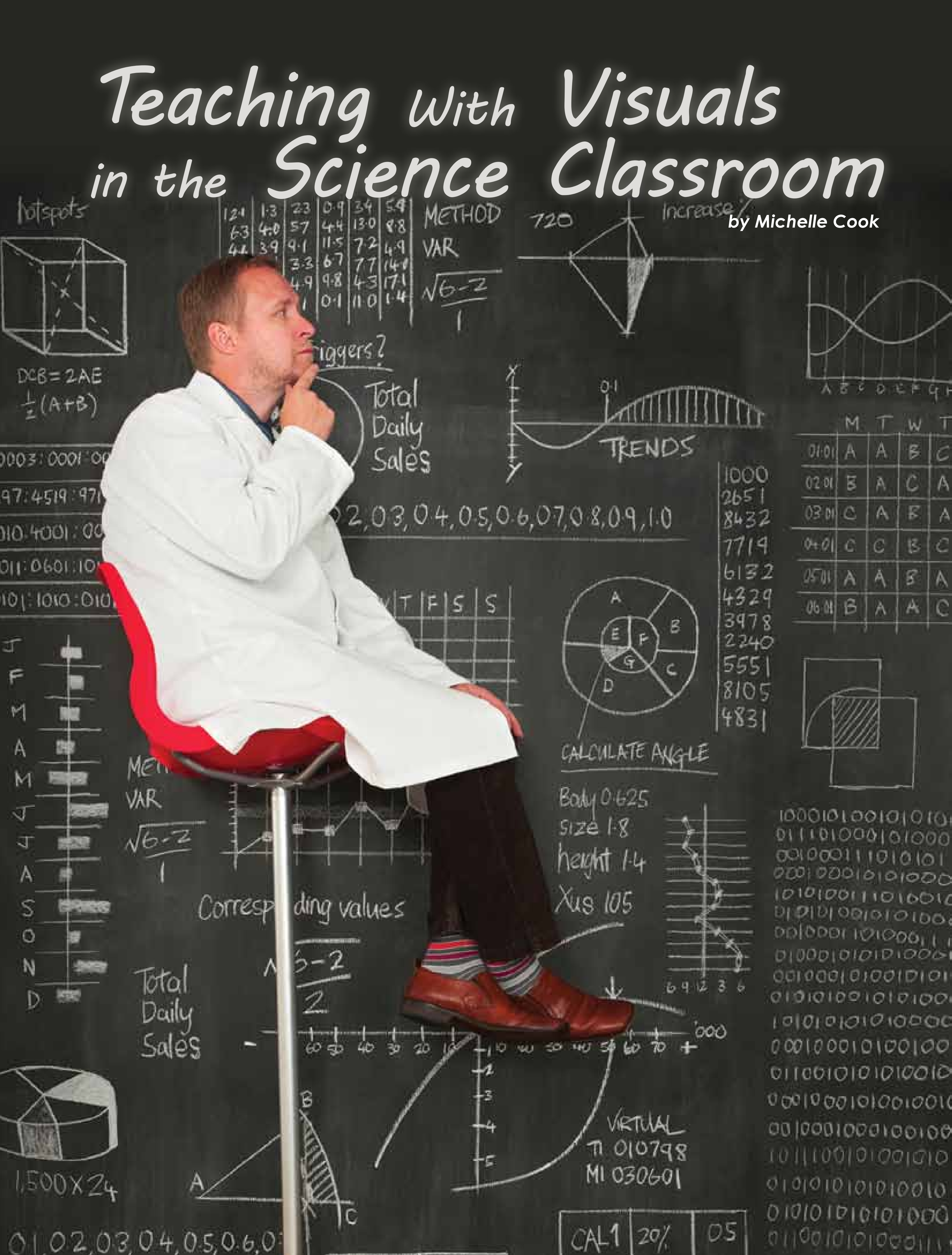
Teaching With Visuals in the Science Classroom

by Michelle Cook



In today's science classroom, a considerable amount of content is presented visually. Illustrations are the basis of visual learning, and typical science textbooks include representations such as photographs, diagrams, charts, graphs, drawings, and tables. A quick inspection of today's textbooks reveals that close to half of the printed space can be accounted for by illustrations. As the number of illustrations has increased in modern textbooks, the relationship between written text and images has also changed. Images, which used to be secondary to the written text, now play a vital role in the understanding of textbook information (Martins 2002). More recently, computer-based instructional materials, such as teacher-designed presentations, animations, and educational games, have become more common. As the multimedia used in classrooms become more complex and interactive, it is important to understand how to best use visuals for science learning.

Visuals play an important role in the teaching and learning of science and should be embedded within and supportive of authentic science inquiry. Most often, visuals are used to depict phenomena and relationships that students cannot observe or experience directly. Some topics in science are too small (enzymes), too large (solar system), too slow (continental drift), or too fast (chemical reactions) to see with the unaided eye. Visuals are also used to display data (distance vs. time graphs), organize complex information (food webs), and represent processes that are difficult to describe (photosynthesis). Finally, teachers use visuals in the classroom to attract attention and motivate students.

Both researchers and teachers believe that visuals have a great deal of potential to help students understand science, but in practice, these visuals do not always live up to their promise. Many considerations need to be taken into account when using visuals. Not all visuals are created equally: Some are poorly designed and may not provide students with new information; some may be too complex for students; and some may be distracting, with too much irrelevant information. Teachers need to make informed decisions about what visuals they use in their instruction. In addition, they must also consider how they will present visuals and how diverse learners might interpret them. The seven suggestions provided below stem from brain-based research and can help students get the most out of the visuals presented in the science classroom.

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Include verbal information with visuals

Research shows that students process visual and verbal information in separate channels of the brain (Baddeley and Logie 1999). Including verbal information (in the form of text or narration) allows students to take in more information than possible with the visual alone. However, it is important to ensure that students are spending time on both the visual and verbal information. Many studies (e.g., Hannus and Hyönä 1999) have indicated that students focus heavily on text and may not even look at the visuals in textbooks and computer-based multimedia presentations.

Integrate verbal and visual information in time and space

The design of the visual should make it easy for students to link the visual and verbal material presented. Visual and verbal information should be integrated in both time and space (Wu and Shah 2004). For example, when an animation is shown first and then explained afterward, students will have a more difficult time understanding the animation, because they are required to hold small pieces of information about the animation in their memory until the animation is explained. Most of their cognitive effort in this case goes toward linking the information, and a deeper understanding of the concept is lost. It is better to present visual and verbal information simultaneously. Likewise, it is better to integrate small pieces of text within a visual rather than placing text below the visual in a caption. For example, it is common to see the stages of mitosis represented in a series of illustrations horizontally across the page with a text caption below the illustrations. In order for students to make sense of mitosis they must match up what the illustration is representing with what the text is conveying. This process could entail students holding a piece of textual information in working memory while they look for how it is represented in the picture and requires a great deal of cognitive effort. A better way to depict this process would be to have arrows indicating the relevant parts of the illustration with text boxes describing the action occurring (e.g., sister chromatids move to opposite poles). Decreasing the physical space between visual and verbal information reduces the effort required by students to link the information.

Use narration over text when appropriate

Studies have shown it is easier for the brain to process spoken text than written text (Mayer, Heiser, and Lonn 2001). In most cases, listening to a narration about the visual would be more beneficial to students than reading text about the visual. Although visual and verbal information are processed in separate channels of the brain, written text is initially processed in the visual channel and competes with the graphic for visual attention. Narration can come from the teacher explaining a graphic or can be embedded within computer-based instructional materials. However, there are times when narration may not be as effective, especially if it's too lengthy, complex, or quick. Students cannot always "play back" a complex or fast explanation like they can reread text. For example, sometimes a teacher's explanation of an illustration may be too complex or too quick for students to process. In that particular case, it would be more beneficial for students to have access to written text so that they may reread the explanation of the graphic until they understand it.

Be careful when providing redundant information

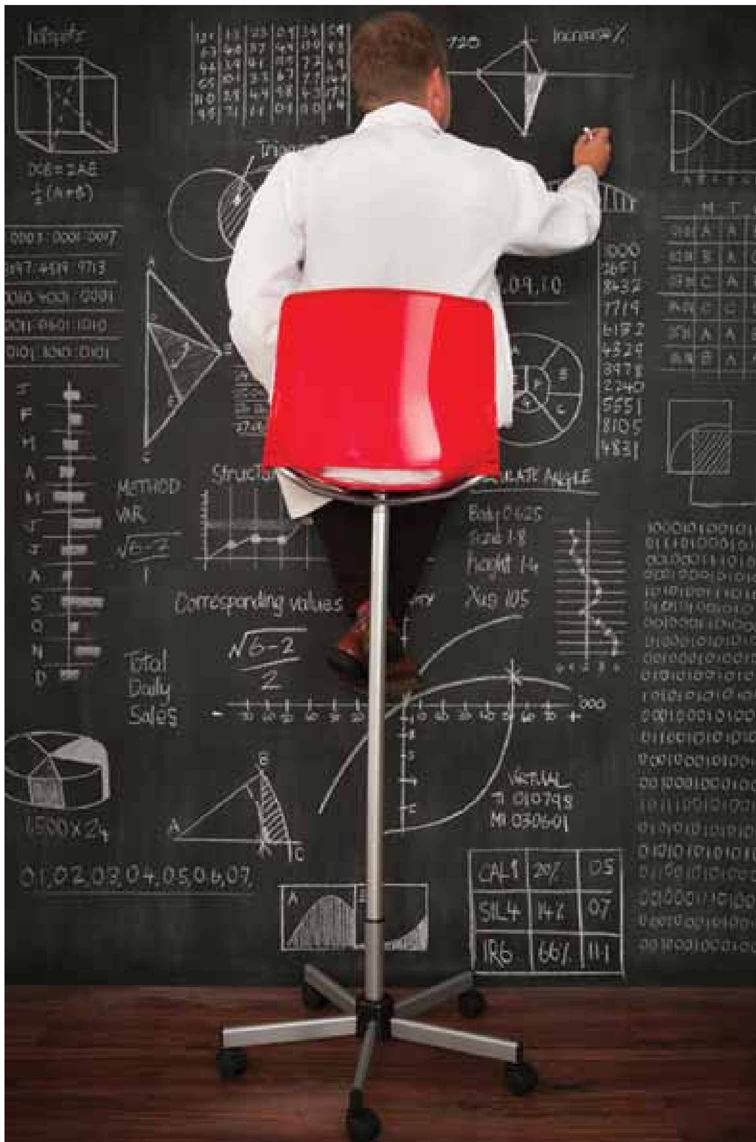
When additional information is provided that is redundant of the visual and verbal information already given, students will have to process the information twice (Chandler and Sweller 1991). For example, if students are provided with two similar visuals of DNA replication, they are using limited cognitive resources to process the same information twice. Likewise, studies have shown that visuals should not be presented with redundant verbal information in the form of written and spoken text. This research could explain why students have difficulty in typical teacher-designed presentations where students are expected to look at a visual, read and copy the text on the slide, and listen to the teacher's explanation. Teachers need to be mindful of the amount of information being presented to students at any one time.

Use animations wisely

Animations represent phenomena that unfold very slowly or very rapidly, or abstract concepts not directly connected to physical objects. While students seem to prefer animations, research has shown them to be advantageous only in certain situations (Lowe 2003). Animations are often complex, transitory, and fast paced, characteristics that make them very difficult to understand for some students. Animations tend to be better than illustrations when representing concepts involving change over time (i.e., motion or trajectory), however, teachers may have to show the animations at a slower pace or successive times; animations with interactive controls are helpful for this reason.

Keep it simple

It would seem that graphics that realistically depict an object would be most useful for learning; however, realistic detail almost always increases diagram complexity. In many cases, simple graphics with less detail tend to be more effective than realistic ones (Butcher 2006). For example, students have a more difficult time understanding the path of blood flow through the heart with a realistic image that preserves the anatomy of the heart and circula-



tory system. With a simplified diagram of the four heart chambers, important parts can be identified while other details are deemphasized. In this way, students are less likely to be distracted by irrelevant information and more likely to understand the path of blood flow. Likewise, text explanations should be kept short. Short captions have been shown to be more effective than lengthy verbal explanations (Mayer et al. 1996). When keeping diagrams simple and explanations short, teachers must monitor student learning to ensure alternate conceptions do not result. It is still important to portray accurate spatial relations and make sure students are able to make connections between the simplified diagrams and the real structure or phenomena.

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Provide guidance

Oftentimes, students are unable to develop deep understandings of concepts by freely exploring visuals on their own (Moreno 2004). Students need instructional guidance and feedback, whether it comes from the teacher, other students, or within computer-based multimedia. A common instructional practice is for teachers to point at graphics in books (Coleman, McTigue, and Smolkin 2011). Teachers cannot assume students know what parts of a visual to focus on and the conventions for interpreting them. Students must be taught how to "read" visuals, much the same way they are taught to read text. Teachers need to be explicit about what the relevant parts of the graphic are, what the conventions of the graphic (arrows, highlighting, etc.) are expressing, and how students should interpret the graphic and connect it to the science content.

Conclusion

The use of visuals is prevalent in today's science classroom. Visuals are common in science textbooks, teacher- and student-developed presentations, and computer-based software. Teachers need to make informed decisions about what visuals to select and how to present them to their students. Using brain-based research to make these decisions can assist teachers in choosing visuals that will help students better understand the concepts represented. ■

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