ED463945 2000-11-00 Visual Literacy and Learning in Science. ERIC Digest.

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ERIC Identifier: ED463945
Publication Date: 2000-11-00
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Source: ERIC Clearinghouse for Science Mathematics and Environmental Education Columbus OH.

Visual Literacy and Learning in Science. ERIC Digest.

In our visually oriented age, science and technology education rely heavily on the use of pictures to present technical information. Today's students live in an information environment saturated with visual images, and educational materials are no exception. Because educational materials must compete for attention in this rich visual environment, all types of teaching resources from traditional textbooks to the latest educational technologies contain a wealth of pictorial representations. In science and technology education these pictures are very diverse, ranging from realistic drawings and photographs to highly abstract diagrams and graphs. The educational emphasis on pictures reflects the widespread use of technical pictures by practicing scientists and technologists across many different fields.

The use of pictures to represent technical subject matter is not new. Ancient pictures from many different countries show that visual information has long been an important means of communicating ideas about our world and how it works. However in more recent times, there has been an explosion in the number of specialized types of graphics developed to represent scientific and technological information. These specialist representations can provide critical information about the state of our world that may have enormous social and economic implications for its peoples. For example, the science of meteorology relies heavily on traditional weather map diagrams as well as more modern remote sensing imaging techniques.

Technological advances, particularly in computing, continually increase the range of imaging techniques that are available to the scientific community. The burgeoning use of pictorial representation has implications for science and technology education. The capacities to both understand and generate technical pictures are fundamental to scientific and technological literacy for students at many levels, from school to university. We could describe these capacities as a form of visual literacy that involves the "reading "and "writing "of technical pictures. It is just as important for students to develop this visual aspect of scientific and technological literacy as it is for them to develop the general literacy required to understand the specialized verbal and mathematical languages they encounter in science. Successful reading of a highly abstract scientific diagram requires very different skills from those required for reading ordinary pictures of everyday content such as photographs in a newspaper or illustrations in a shopping catalogue. This means it is essential that today's students develop the general visual literacy skills required for dealing with scientific graphics, but they must also learn about particular types of scientific pictures that actually form part of the content of a specific field of scientific or technological study.

VISUAL LANGUAGE

The ways pictures are used in everyday life can give the misleading impression that visual language is somehow generally much easier to understand and more universal than verbal or mathematical language. For example, international airports all around the world use various graphic symbols to present information to people from many different language groups. By avoiding the need for multiple translations, these graphics greatly simplify the task of conveying fundamental information. However, this information concerns basic, everyday matters that people in general are familiar with and represents them in a very straightforward way. In contrast, the forms of visual information that scientists and technologists use are far more complex and esoteric. The specialized nature of scientific visualizations means that people do not learn to deal with them as an incidental result of their normal interaction with the everyday environment. Rather, they must engage in specific learning activities that help them to develop the knowledge and skills required to interpret these very particular types of visual representation. Part of the reason for this is that the content depicted in these visuals is quite unfamiliar to everyone except specialists in the scientific field concerned. However, there are also aspects of how content is depicted that make these visualizations challenging for the uninitiated. In particular, the depiction of the subject matter in scientific visuals is often not meant to be taken literally. Rather, diagrams and other technical illustrations depict their content using a host of specialized graphic conventions that extensively manipulate and even grossly distort literal reality. To interpret these pictures properly, the viewer must know about these conventions and be skilled in decoding them in an appropriate manner.

DEVELOPING VISUAL LITERACY

Teachers must develop students' capacities to understand and properly interpret specialized technical visuals. Teaching of the necessary knowledge and skills should begin when children are quite young, even before they begin formal studies of science and technology. One approach is to introduce young children to graphic conventions that are widely used in depictions such as scientific diagrams by having them devise simple drawings that actually use these conventions. However, rather than illustrating unfamiliar scientific topics, this should be done in the context of everyday subject matter. In other words, the content of the visuals would be very familiar to the students, but the way it is to be depicted would be highly diagrammatic. For example, teachers could guide students through a number of stages to help them develop their own diagrams of a simple commonplace object such as a piece of fruit. Starting with the real object, the teacher could show students how to use a range of diagram techniques to devise a picture that communicates information about the object in a scientific manner. So, if a teacher decided to use an orange as the subject matter for a diagram-drawing exercise, one of the things that could be done is to introduce students to the idea of a cross-sectional view. This is a technique widely used in scientific and technological diagrams as a way of indicating internal structures that are normally hidden from view. It is a simple matter to cut the orange in half, place one of the halves cut-face down on a photocopier to produce a photo-like image of the inside of the fruit. This photocopy could be the starting point for students to gradually modify the image in order to produce a more diagrammatic depiction. This would involve processes such as simplifying the image into a line drawing, omitting unnecessary detail, removing natural irregularities to produce a more 'geometric' result, and identifying key parts of the structure by means of shading or color coding. Initial activities of this type could be followed by using objects for which dynamic change as well as structure must be depicted. For example, a simple device such as a plastic garden irrigation tap could be dismantled and its functioning represented diagrammatically. This type of exercise could be used to show how other diagram conventions such as arrows, dotted lines and sequential pictures can be combined with the cross-sectional convention covered in the previous example. Where aspects of the subject matter would be artistically difficult for young students to draw by

themselves, teachers could provide partly-drawn pictures so that students have only to add simple lines and shapes to complete the representation. Alternatively, teachers could provide a "kit" of pre-drawn pieces for the diagram which students would then assemble into a finished product.
Having children devise their own "technical pictures" requires a significant change in the way drawing is typically treated in elementary school. In most classrooms, children either copy pictures provided by the teacher or textbook, or draw their own pictures as a means of self- expression, Rarely are they asked to produce original drawings that provide the type of clear and precise visual explanation that is found in technical diagrams. However, it is unreasonable to expect students to acquire all the required capacities for dealing with technical diagrams by such drawing exercises alone. As students move into formal studies of science, there are occasions when the teacher needs to present them with ready-made diagrams as well as other forms of scientific image. In these cases, students' capacities for dealing with technical pictures are more likely to be developed if extensive scaffolding is provided by the teacher. For example, instead of requiring students to copy down a finished diagram, the teacher could gradually build up the depiction piece by piece in a way that emphasizes the logic of the subject matter. The value of this sequential type of approach would be further enhanced by accompanying the drawing process with a suitable commentary and questioning that emphasizes key aspects of the subject matter. On many occasions, students are faced with a technical picture in a textbook or other resource that is intended to explain the to-be-learned content. However, these pictures are often quite difficult for students to interpret effectively because they do not know how to read such pictures effectively. Just because teachers have no trouble reading a picture, we should not assume that it is equally comprehensible to students. Teachers should consider providing quite explicit guidance to direct their students through the information that is depicted so they explore the picture in detail and develop an understanding of its internal logic. Supplementary exercises based on an existing picture but which require students to analyze, elaborate or modify the original in various ways can also help to improve comprehension.

CONCLUSION

Visual literacy is an essential component of science and technology education today. However, it is an aspect of learning that is relatively neglected by teachers. One reason is that teachers generally assume that pictures are self-explanatory and always function to make their subject matter easier. Unfortunately, comprehension of the specialized pictures used in technical fields requires knowledge and skills far beyond those required for everyday pictures. In order for teachers to address this neglected aspect of science and technology education, they need both a better appreciation of the demands of technical pictures and a knowledge of teaching strategies that will help to develop students' visual literacies in this area. Science teacher education should cover this topic, but support is also needed for experienced science and technology teachers. At present, resources to help teachers develop visual literacy are limited, and there is a great need for further work to develop practical teaching strategies and resources.

FOR FURTHER INFORMATION

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Note. Other work in this area can be located by searching the ERIC database online (www.askeric.org) using various combinations of the following descriptors: visual literacy, science education, science curriculum, science activities, and science instruction.

This digest was funded by the Office of Educational Research and Improvement, U.S. Department of Education, under contract no. ED-99-CO-0024. Opinions expressed in this digest do not necessarily reflect the positions or policies of OERI or the U.S. Department of Education.

Title: Visual Literacy and Learning in Science. ERIC Digest.
Document Type: Information Analyses---ERIC Information Analysis Products (IAPs) (071); Information Analyses---ERIC Digests (Selected) in Full Text (073);
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Descriptors: Elementary Secondary Education, Higher Education, Science Education, Scientific Literacy, Visual Literacy, Visualization
Identifiers: ERIC Digests
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