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ABSTRACT

Given the role science and technology play in economic and social development in today's world, scientific and technological literacy must be given priority as an essential component of basic education. The significance of the visual component of literacy has increased with advances in technology and picture and image usage. The United Nations Educational Scientific and Cultural Organization's (UNESCO) "Project 2000+" and the United States' Project 2061 are examples of the way scientific and technological literacy objectives can be pursued. No sufficient thought has been dedicated, however, by science teachers to the procedure of image and symbol formation and the formation of concepts in human cognition. Examples of effective use of symbols can be found in the petroglyphs and drawings of the American Indian culture. Understanding the visual basis of human thought can bring about a more intelligent equilibrium between the written word and the visual-acoustic components in acquiring literacy. Scientific Visualization, a new movement synthesized from the parent fields of computer graphics, simulation, image analysis and applied art using the power of computers, multimedia, and hypermedia techniques to transform information into visual symbols, is recommended as a worthwhile teaching innovation to address the issue of imagery and concept formation. (Contains 19 references.) (MAS)

Imagery in Scientific and Technological Literacy for All

Ora Silverstein

The visual component's significant place in research and study of the sciences is already known. New technologies, empowered by means of media communication systems are developing. Multimedia and hypermedia techniques enable creative usage of pictures and change the methods of learning in general and of the exact sciences and natural sciences (Silverstein, 1992). These substantial changes which took place in the 20th century not only enable but also obligate research and learning by visual-pictorial methods in the 21st century.

Today, the term "literacy" is the key for the requirements that educators and teachers have to fulfill the world over.

The year 1990 was declared International Literacy Year (ILY) by the United Nations. During ILY there were two major conferences which dealt with the theme of literacy and basic education. The first was the World Conference on Education for All held in Jomtien, Thailand in March 1990. After that the forty second session of the International Conference on Education (ICE) was dedicated to "the struggle against illiteracy".

There are many definitions of Literacy (Wagner, 1991) and the decision by the international institutions to bring literacy to the entire world caused research and clarification of this term.

One of the most important consequences of studying the meaning of literacy is the definition of a new term: "Scientific and Technological Literacy", born from the acknowledgment of the importance of science and technology (Haggis, 1993). UNESCO, the renown United Nations Educational Scientific and Cultural Organization, decided to adopt measures which, if indeed adopted, will justify the letter "S", standing for "Scientific", in its name.

It was stated, following general agreement at UNESCO, that given the role science and technology play in economic and social development in today's world, scientific and technological literacy must be given priority as an essential component of basic education (Bowyer, 1990).

UNESCO promoted an inter-national activity called "Project 2000+", whose objective is to provide Science Literacy for all in the 21st Century. For this huge task, representatives from 80 countries gathered at the Scientific International conference called Science Education in Developing Countries - from Theory to Practice which was held in Jerusalem (Israel) in January 1993. Leading researchers in the teaching of sciences, as well as representatives from under-developed countries participated in the conference. The conference was established for sharing and devising ideas for reaching the next step of the plan for proper implementation in various countries.

It was agreed that: "scientific, as well as technological literacy stand out as goals of the science education needs for the 21st century, if developing countries are to understand and participate in science and technology (Bajah, 1993).

It was also recommended that developing countries should set up National Tactical Committees to plan their Science Education Programs for the year 2000+.

Following the conference, a work seminar was held, called the International Forum on Scientific and Technological Literacy for All (UNESCO, Paris 1993). 450 representatives from the whole world took part in the Forum. Work was carried out in groups, according to predetermined objectives and guidance, and following a preliminary preparation and reading of literature. The questions and conclusions raised were summarized in the Final Report and "The Project 2000+ Declaration".

Today we may say that there is an international consensus concerning the objectives and means of distribution of Scientific and Technological Literacy for All, and there exists an infrastructure and operative network for the implementation and continuation of the project.

Project 2061 in the United States is an example which enables us to follow the activities of the above mentioned objectives. This is a so-called "SATS" approach, (Science, Technology, Society), which is presently the most common method of science teaching in the Western World.

The "Project 2061" was launched in 1985, the year when Alley's Comet passed close to Planet Earth. It is a long-term reform initiative for science literacy of the American Association for the Advancement of Science (AAAS). Its goal is to improve the quality, increase the relevance and broaden the availability of the natural and social sciences, mathematics and technology for all students (kindergarten through twelfth grade) who would live to see the return of Alley's Comet in 2061.

Science literacy, as defined in Science for All Americans (Project 2061's 1989 report): is concerned less with students mastering these disciplines, than having them understand the world through the "eyes of science". Project 2061 is trying to establish "a vision for achieving science literacy" (Rutherford, 1993). These successful metaphors are currently without link to Visual Literacy Theories.

It should be emphasized that there is a huge gap between the declarations found in literature written in the course of the two last years within various academic and managerial frameworks on Scientific and Technological Literacy for All, that certainly mean well, and the concept accepted by those who are conscious of the substance of Visualization. The concept of Visualization, which has been widely written about by Roth (1993), Tufte (1990), DiBiase (1990) and also others, has significant consequences regarding the correct method of acquiring Science Literacy.

DiBiase speaks about "scientific insight through visual methods". One of the most important examples that he exposes is Kekule's vision of a snake, as a visual metaphor for the ringed structure of benzene. This example is quoted from Jung (1968), who explains that the German chemist (of the 19th century) dreamed about a snake that holds his tail in his mouth, a most ancient symbol. Kekule deducted from this dream his interpretation to the well-known ringed structure of benzene, where 6 carbon atoms are tightly linked to each other by strong covalent bonds.

DiBiase writes that since Plato, who warned of the illusory nature of sensory images, western educational systems have stressed fluency with words and numbers as the legitimate modes of reasoning. Graphics, which depend on visual perception, are less valued because perception has been assumed not to involve thought.

DiBiase mentions Rudolf Arnheim, whose book Visual Thinking (1969) has great importance for all those who deal with acquiring Scientific and Technological Literacy for All. While all the written material dealing with science education in the 21th century is abundant with words and numbers, but almost without any tables or illustrations and the manuals for all those who deal with Science teaching are full of abstract phrases, this book emphasizes the subject of Vision in Education.

People who deal with teaching of sciences in the western world are aware of the results of research conducted in the last decade, showing that most students have misconceptions about physical - natural phenomena (Wandersee, 1986). However, no sufficient thought has been dedicated in science teaching to the procedure of image and symbol formation and the formation of concepts in human cognition. Howard (1987, pp. 16-37), states that the structures that are used to build perception are existing images and symbols. Following research observing more than 1000 pupils and teenagers, Silverstein & Tamir (1992), have shown the importance of visual thinking in understanding scientific concepts. Their research agrees with the theory of Howard (1987) based on Bruner concluding that a person has a mental image of his perceptions as soon as at the end of the first year of his life.

Arnheim (1969, pp. 294) concludes by saying that "visual perception lays the groundwork of concept formation. The mind, reaching far beyond the stimuli received by the eyes directly and momentarily, operates with the vast range of imagery available through memory and organizes a total lifetime's experience into a system of visual concepts".

Dondis (1973) gives examples of symbolism and states that abstraction toward symbolism requires ultimate simplicity. This way of thinking is complementary to the many examples appearing in books dealing with Picture Writing of the American Indians (Mallery, 1972), such as the petroglyphs in Arizona that are characteristic of the drawings of the Indians in America (Stokes & Stokes, 1991). Pictures drawn by Indians of the Hopi tribe in Arizona join those of Indians in Colorado, Utah, New Mexico and Nevada. You can find there pictures dealing with abstract scientific concepts, such as "weather" and "water" and with technologies used by those tribes. You will see pictures of snakes used as symbols and pictures of various plants and animals together with pictures of folklorist motives (William & William, 1980). You may encounter some of these pictures even today, in pupils' notebooks and in modern science books. One example is a picture describing a liquid in a bottle, with dots scattered above it (Martineau, 1973). The discovery of such a picture in a culture that apparently was not acquainted with the atomic particles of the substance, is most interesting.

The Indian culture, which did not have written verbal language and used sign language and picture writing for communication, is a proof of Arnheim's theory. The Indians used visual symbols to express their thoughts and establish human communication. The concept of "life" was illustrated in this culture as a circular drawing. In biology, the term "life-circle" is one of the most important ones and is connected to the understanding and perception of the life cycle that we try to teach children in elementary school.

A tree is pictured schematically in the Indian picture writing, as it would appear in a modern book of botanics. In order to express "sunrise" and "sunset" in picture writing, the Indians used drawings of circle sections - which proved their understanding and awareness of the fact that the world is round. There is no doubt that a deep insight of the pictures, symbols, sign language and narration in Indian culture, as compared with other primitive cultures that existed on earth and the understanding that human thinking is based upon a collection of stimuli stored in the individual and universal memory, may largely contribute to the choice of the correct method for science teaching in the 21st century.

Understanding of the visual basis of human thought could bring about a more intelligent equilibrium between the written word and the visual-acoustic components in acquiring Literacy for All, including Scientific and Technological Literacy for All.

It should be noted that there is an extreme variety of teaching levels and methods in science teaching all over the world, and also among the developed countries. Verbal teaching, which ignores the use of media technologies is still being used in many places. There is the other extreme of using the so-called Scientific Visualization in a number of schools and universities.

Scientific Visualization is a new movement synthesized from the parent fields of computer graphics, simulation, image analysis and applied art using the power of computer, multimedia and hypermedia techniques to transform information into visualizable form (Jolls, 1991). It is worthwhile using these innovative ideas and technologies in order to feed the visual desolation that exists when teaching in places and societies which have lost the natural attitude towards acquisition of knowledge and are now on the forefront of educational performance.

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Endnotes

1. The summary of Forum 2000+ is included in the following publication: UNESCO. (1993). International Forum on Scientific and Technological Literacy for All. Final Report.

2. The article summarizes the author's participation in both conferences mentioned on Scientific and Technological Literacy for All: the first in Jerusalem and the second in Paris (1993). Also participated in the preparatory session (held in Geneva, 1994) for two large women's conferences which will be held in Japan and China (1994) and will deal with girl child education. Visits to Africa and Russia (1994) and activity with the department of education in own city of residence enabled her to become acquainted with various educational realities.

Acquaintance with pictography of Indians in the United States is a result of visits to a number of National Parks and Indian reservations in the US, in 1992.