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AUTHOR Silverstein, Ora; Tamir, Pinchas
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ABSTRACT

Today's literature on the psychology of learning points out that intelligent learning is the formation of concept structures communicated and manipulated by means of symbols. The study presented in this paper examines the learning of biology by means of unguided viewing of television using two different television symbol systems: story animation and documentary. The Story Animation Code consists of unusual complex illustrations and the Documentary Code is made up of scientific symbols--models, schematic drawings, and other drawings used in the teaching of science. Results demonstrate the educational potential of television in out-of-school situations. Viewing television broadcasts presenting biological concepts resulted in a significant improvement in knowledge. Gain, calculated by posttest minus pretest scores, was found in both codes and the students were equally sympathetic to them. Better knowledge gain and more positive attitudes were found towards the story animation code, but the gain was also accompanied by misconceptions. Results support the theory that perception of the visual field does not depend merely on sight-related factors. Even when no similarity exists between the pictorial representation and reality, a series of inferences can still be drawn from the picture by using the information it contains about itself. (Contains 16 references.) (AEF)

THE ROLE OF IMAGERY IN LEARNING BIOLOGY SCIENCE THROUGH TELEVISION

by
Ora Silverstein and Pinchas Tamir

Theoretical Background

The Information Age and the Role of Pictorial Representation

Telecommunication is becoming a main source of stimuli, perception, and knowledge. It has been stated that visual communication is taking over verbal communication and that pictures have become the main method of transmitting information (Gombrich, 1972). It has also been declared that television is the main source of knowledge in our civilization (Metallinos, 1985; Pettersson, 1989). Television enables viewers to perceive living creatures and natural phenomena in the macro and microcosmos. Therefore, it is important in acquiring a knowledge of the natural sciences outside the scope of the school. Although there has been progress in research on learning through television, the learning of scientific concepts from television has hardly been studied. Our research (Silverstein & Tamir, 1991) is concerned with this subject and studies the perception of symbol systems that represent concepts in biology. It compares two different television symbol systems: Story animation and documentary, representing the same biological concepts.

According to Howard (1987), Bruner identifies certain stages in child development starting from visual experiences and progressing to abstract thinking. The development starts from the *enactive* stage in which the child *sees* the world by means of action. At the end of the first year he/she proceeds to the *iconic* stage, in which comprehension of the world is through pictures, and the child acquires a *mental image* of his concepts. From the age of seven the *symbolic* stage begins, in which the child sees the world through its representation by symbols.

Norman (1980) states that environmental stimuli are the main source of human perception. He suggests a model of the human cognitive system which includes sensual perception, memory processes, motivation, thinking, emotions, and motor functioning. He calls these complex cognitive processes information processing. Memory processes are important in the complex of cognition and modern theories explain the forming of memory, the ability of recognition, and the dynamics of the process of conceptualization. Experiments have proved that memory recording begins with *sensual memory*. The impressions of sensations accumulated in the sensual memory are called *images*. Images pass into the short term memory and later become accumulated into the long term memory. The representation of an object or creature, say a certain animal, plant, or microorganism, is a result of a sensory act comprising the perception of sight, smell, voice, and its name (word). Therefore, the stimulus data from our environment come from objects and living things and also from symbol systems. Gregory (1978) studied the recording of visual impressions. According to him, the eyes supply the brain with information transformed into a code of nerve activity. Gregory's and others' research allow for the existence of nervous centers in which impressions are recorded and stored in the brain. The symbol systems perceived by the senses are called codes. Since television experience involves the senses of both sight and hearing, the impressions of television are transferred to memory as images.

Learning, Conceptualization, and Symbol Systems

Today's literature, concerned with the psychology of learning, points out that intelligent learning is a formation of concept structures communicated and manipulated by means of symbols.

According to Olson (1974), a symbol is any sign, event, or phenomenon that can be used in a referential way and which can potentially be organized into systems. Symbol systems are discussed in philosophy, cognitive psychology, and the theory of art and semiotics. There are different visual symbol systems. An icon is a picture similar to its object; painted pictures or photographs are icons. A cartoon is a picture that gives information about the object, person, or situation represented in an exaggerated way. The still cartoon and animation that gives the sense of life and motion are symbol systems that imitate their references using exaggeration for emphasis in contrast to icons that resemble their references more realistically. Icons are the type of pictures shown in a documentary movie.

From Vision Through Perception to Conceptualization

In order to understand human cognition, it is best to consider two complementary sources. The first is perception as a neurobiological process connected to the function of the central nervous system, and the second is the influence of science and art on perception. The discussion of one of these without the other will give an incomplete picture. There is no argument about the recent findings (Gregory, 1978; etc.) from neurophysiological studies about the anatomy and function of the eye, retina, optic nerve, and brain vision. However, there is a controversy about the influence of both general and personal prior knowledge on perception and visual imagery which will be discussed here.

Perception and Imagery

Perception is explained as a process taking place in two stages. The first stage is sensation. In the second stage the stimuli become meaningful and then they develop into units of knowledge. Wartopsky (1976) states that: "The world perceived by the organism is a map or an image of its activities" (pp. 27-28). He explains that sight is not merely a result of the operation of the biological tool that developed by evolution--the human eye.

In his opinion the self creates a new different world--that is, a cognitive construction--and the representations created become models and theories in science and pictures in art. According to cognitive psychology, an image is a sketch of a sensation that is stored in the sensual memory and as such it is a mental representation of anything no longer available to the senses. A visual image in the brain is parallel to the optical image of an object produced by an optical system, for example, the image produced by a camera. As images are pictures of reality, the act of imagining is the manipulation of mental pictures as opposed to the manipulation of concrete objects.

Perceptionalism and Intentionalism

The perception of pictures is a response to basic forms according to the laws of Gestalt theory; the basic unit of understanding in visual thinking is the percept (Arnheim, 1974; Olson, 1974). How does the perception from pictures occur? Perceptionalism and intentionalism summarize the philosophical semiotic and psychological schools of thought on this subject.

Perceptionalism is an approach based on Gombrich (1960) and Gregory (1978); they say that the picture does not have its own meaning but the viewer creates for himself a unique meaning based on his prior observations, experience, and expectations.

Intentionalism (Goodman, 1976) is based on a semiotic approach which says that in any picture there is an inherent meaning and the viewer is meant to reveal it. The meaning of a picture is determined by the artist, and as such it has its own essence which does not depend on the individual viewer.

In Goodman's (1976) opinion, presentation of symbols in science and the arts is based on convention and is thus valid by a semiotic or social agreement. Goodman also distinguishes between a realistic representation and a representation that has a dissimilarity to reality. Our research deals with the perception of biological concepts in two symbol systems, realistic--the documentary code--and non-realistic--the story animation code. Plato, in his writings, demanded that a picture be similar to reality. In the communication systems that serve us today pictorial representations are either realistic or they represent reality.

Gombrich (1972) who is of the same opinion as Gregory, does not agree that there is an *innocent eye*. He explains that the perception in the brain of the image produced by the visual field is a function of both the pictorial representation and other aspects such as history, culture, and psychology. Most pictures do not represent simple objects but ideas that are *conceptual schemata* (abstract generalizations of an object or a group of objects) kept in people's brains. The assumption of this approach, also agreed by Goodman and Wartofsky, is that visual thinking is done by cognitive representation systems comprised of visual images. The same process works for other representation systems like linguistics and music. Reality and imagination relate to the way a person tends to represent the stimulus data to himself in his schemata. Blich (1989) adds that there are two groups in each audience. The first one relates to the pictorial as if it were the real world. The second group knows that this representation is not real. In our research this was evidenced by the differentiation between the groups with regard to animistic versus causal thinking. The theories of cognitive psychology about visual thinking and the empirical results of our research lead to the acceptance of Gombrich and Blich, and thus to the rejection of the existence of an *innocent eye*. A famous example, the well known picture of Jestrow, is given by Gombrich (1972):

What do you see in the picture? (a rabbit or a duck?)

There are two images merged into one and seeing the rabbit or duck depends on the viewer's ability to discern from the picture one of the two images.

From Percept to Concept

According to cognitive psychologist Howard (1987), the structures that are used to build perception are existing schema, images, and symbols. The schema is a sketch that represents the outstanding components of its reference. For example:

Schema of a face:

Howard states that the schema is associated with different stimuli and that its action is like a filter, it enables only part of the information to pass through. The image is more complicated than the schema. An image of a face is a detailed picture of someone that we remember very well. The symbol is an abstract way of referring to the particular image.

Howard (1987) asserts that reality is experienced after it has been filtered through the categories or the concepts.

According to Howard a category is a class into which stimuli are placed according to some similarities and a concept is a mental representation of a category.

Every stimulus can be placed in one of many different categories. A house can be a place to live, obstacle, burden, investment, or *home*. Ausubel, Novak, & Hanesian (1978) had used the example of a house to show that when someone refers to *house* he refers to his personal projection of it. Personal experiences cause the idiosyncratic character of the concept to be built. They claim that experience undergoes the procedures of selectivity, abstraction, and schematization to form the concept, and thus the concept is not a direct representation of sense data.

The Ongoing Change of Human Perception

McLuhan (1964) states that television has components that are analogous to comics and cartoons. In the cartoon there is an exaggeration of an aspect that causes dissimilarity to its object. Television images are unrefined, like those of the comics. In the three media, television, animated cartoons, and comics the viewer participates in a *fill-in* and *do-it-yourself* activity. McLuhan uses the concept television image and describes its characteristic as a raw image. According to McLuhan there has been a fundamental change in human perception and cognition caused by the communication media and in his opinion there is no one approach that fits this enormous change. There is still no unified theory that explains this phenomenon.

The Main Goal

The main purpose of the research was: To study the learning and natural-sciences by means of unguided viewing of television.

Methods

Study of Broadcast Content

Our study examined the learning of biology by means of unguided viewing of the medium of television using two different codes. The perception of the biological concepts in the two subjects: *The Cell* and *Birth* was represented in both story animation and documentary form. In the course of the study a content analysis of the dual-coded broadcasts was made. Broadcast content analysis was done before; Erdman (1991) did a formal analysis of the format and message of the teaching film. However, in the broadcast content analysis, instead of a shot-by-shot analysis of the visual and audio track that were used by Erdman, in our study broadcast scripts and videos in French, English, and Hebrew were used at different stages of the study. The scripts that were used provide a full documentation of the verbal audio track. Analysis of the broadcasts, preparation of the tools, the launching of the study, and analysis of the findings gave rise to a growing familiarity with two visual systems of symbols, each with its own unique advantages.

The Story Animation Code consists of strange and complex illustrations that are unusual and novel. These are artistic symbols representing the content of biological concepts that are usually represented in pictures or scientific symbols.

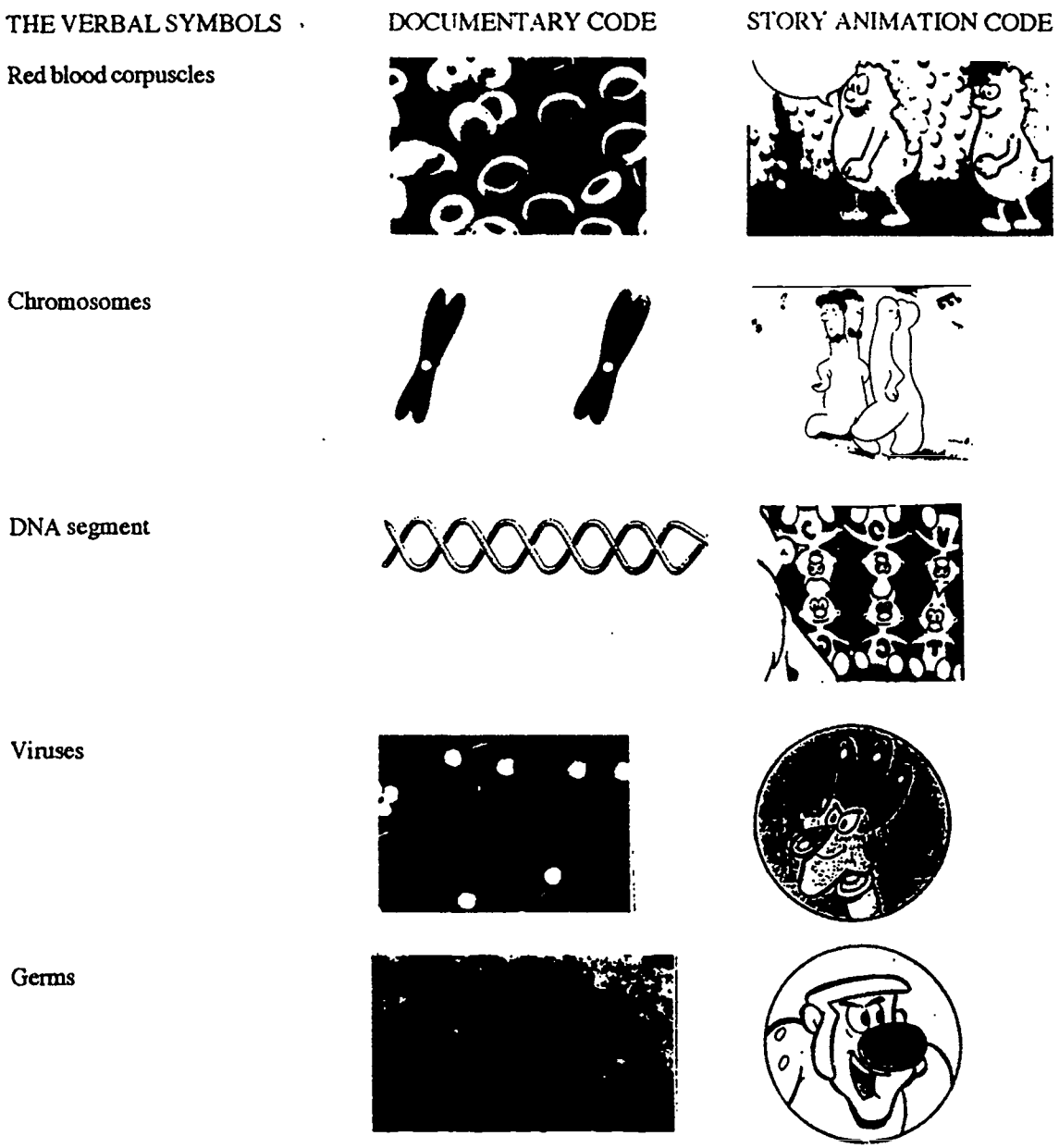
The Documentary Code is made up of scientific symbols--models, schematic drawings, and other drawings used in the teaching of science.

Figure 1 gives examples of a few biological concepts represented differently in the two codes. The verbal symbols in the table represent the scientific concept in words and the pictures represent the visual symbols.

Tables 1 and 2 show the distribution of concepts included in the broadcasts which were investigated in the research.

The questions dealing with cells, organells, and substances are used to test

Figure 1. Examples of Visual Representations of a few Biological Concepts Examined in the Research.



concepts, the perception of which is based on the schemata, categories, and images of these subjects. The questions that deal with the understanding of processes test a higher cognitive level based on a concept set that is basically visual. For example, images of DNA and chromosome structure help to understand the genetic code.

This paper focuses on learning of biological concepts. Table 2 presents the tests used for evaluation and their range of scores.

Gain was calculated by post test minus pretest scores. Comparison between the groups was done by F tests and T tests in dependent samples and independent samples. The influence of independent variables was estimated and expressed by effect size. Frequency distributions were calculated for background and attitudes.

Table 1. The Biological Concepts as Represented by Items in the Knowledge Test

SUBJECTS	CONCEPTS	TESTS & ITEMS TEST 1	TEST 2	TEST 3
SUBJECT THE CELL				
Processes & concepts	Nutrition, digestion	1	6	
	The living cell	2,4	4	1,9
	Genetic code	7,8	11,12	8
	Cell proportions	10	3	
	Breathing	8		
Substances	Oxygen	10		3,7
	Enzyme	9		1,4
	Protein	3	2,9,10	
	Sugar			10
	Fat			10
Cells	Red blood corpuscles			3
	White blood corpuscles			5
Organells	Chromosomes			8
	Cell nucleus	5		7
	Mitocondria	15		4
	Cell membrane		6	
Difficult concepts	Energy	1,5,7,8		
		1,6		
	Permeability	3,13,1,4		
SUBJECT BIRTH				
Processes & concepts	The living cell	2,4	4	
	Cell division	4		
	Genetic code	7,8	11,12	5,7,9
	DNA duplication			8,11,12
	Cell mitosis			6,11
	Pregnancy			5
	Sex determination			9
	Birth	4,8		10
	Cells, tissues, organs	2	4	13
	Cell proportions	10	3	
Cells	Ovum			3
	Fertilized ovum			4
	Sperm cell			3
	Red blood corpuscles		3,5,7	
Organells	Chromosomes		8	4,6
Substances	Proteins	2	2,9,10	
	DNA	8		
	Enzymes	1		
	Oxygen	10		

Data Analysis

Table 2. Tests Used for Knowledge Gain Measurement

Test No.	Abbreviated Name	Type of Test	No. of Items	Evaluation of Open Questions	Maximum Score
1	STK	Open questions	10	According to 6 categories	50
2	MCT	Individual report	16	5 categories	80
3	ATQ--cell	Multiple choice	9	correct answers	9
4	ATQ--birth	Multiple choice	13	correct answers	13

Titles of the Tests--Key to Abbreviations

STK	State of Knowledge Test
MCT	Misconception Test
ATQ	Anthropomorphic Teleologic Questionnaire
ATQ-cell	ATQ subject: The Cell
ATQ-birth	ATQ subject: Birth

Summary of Research Findings

This summary covers the findings of both qualitative and statistical analysis that were carried out. The results present a promising picture of the educational potential of television in out of school situations.

1. Viewing television broadcasts presenting biological concepts resulted in a significant improvement in the knowledge.

2. Gain was found in both codes examined, namely the documentary code and the story animation code.

3. The students/subjects were equally sympathetic to the two codes examined.

4. The two student groups differed in knowledge gain and attitudes; among the technological students there was greater knowledge gain and even more positive attitudes towards the story animation code.

5. Gain was accompanied by misconceptions. There was a relative decrease in causal explanations in favor of anthropomorphism and teleology following the screening of the story animation in the topic of the living cell. No such effect occurred in the subject *Birth*. On the other hand, regarding the subject *Birth*, an increase was registered in the number of causal statements following the screening of the story animation code.

Discussion

The process of visual cognition may be seen as a set of stages in information processing: visual object or symbol -> visual stimulus -> attention -> perception -> image -> memory -> visual thinking -> solution (formation of the concept) -> reaction. Preceding the solution stage, other cognitive processes from verbal sources merge and only then the reaction begins. Attention depends on motivation which is based on prior knowledge and personal factors, as well as factors arousing interest and curiosity that are embedded in the stimulus such as the novelty of the stimulus or an inconsistency between the stimulus and its context.

The results of our study, namely the exhibiting of knowledge gain following the viewing of the story animation code, support the perception approach of Gombrich (1972) and Gregory (1978) which claims that perception of the visual field does not depend merely on sight-related factors. In certain respects we see what we believe. Our research results substantiate Gombrich's claim of the non-existence of an *innocent eye*. Even when no visual similarity exists between the pictorial representation and reality, a series

of inferences can still be drawn from the picture by using the information it contains about itself.

The notion in our study of pictorial representation regarding the biological terminology goes beyond sight itself and must be attributed to the viewer's prior conceptual knowledge. Furthermore, the findings of this study affirm McLuhan's (1964) claim that the television image leaves room for *filling-in* by the viewer. Any television image is unprocessed and unrefined, like that in comic books (McLuhan, 1964). Since the broadcasting of the story animation is a kind of televised code of comics, the viewer needs to do a double fill-in utilizing his prior knowledge.

This means that the story animation code portrays biological concepts using symbols, and it appears that viewers perceive the visual message employing schemata and images that exist in their memory. Identification of the animated shapes using the conceptual system is a process of translation of the coded television message. The term decoding (rather than the more novel *translating*) bests describes this process of identification which is carried out, according to Blich (1989), by way of:

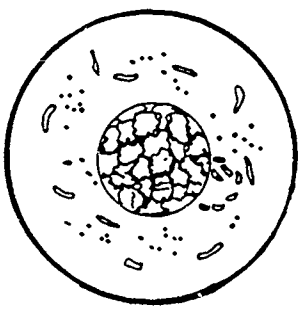
1. Projection of the viewer's prior knowledge on the visual message.

2. [illegible]ling-in of the picture being viewed using prior knowledge and preconception.

Schemata and pre-existent images are employed in the decoding process for the identification of visual symbols.

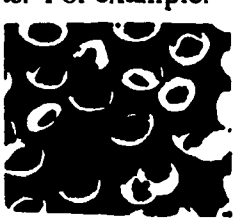
The notion of scientific symbols as visual symbols was examined for the first time ever in this study. Two codes were examined: The documentary code in which biological concepts are presented as *scientific symbols*, and the story animation code in which the same concepts are presented and portrayed as *artistic symbols*. The questions proposed in this study examined knowledge gain and attitudes derived from the imagery potential of the subject. The focus was on scientific symbols and the creation of their *scientific images*. Schemata and images based on conventional scientific symbols are used in deciphering. According to Howard (1987), schemata serve as a filter and only part of the information is passed through them. Consider, for example, a student who knows that the living cell is the smallest living unit of structure and activity that exists. His schema of the single cell appears to be like this:

Schema of a Cell

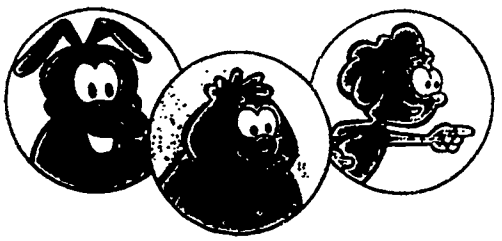


The students see in the story animation broadcast what they *believe*, or rather *know* about the cell, and rely on the image of the already existing concept. The animation code, it should be recalled, contains symbols that arouse curiosity, are stimulating and motivating, and encourage positive attitudes. The information presented in the broadcast is filtered and accumulates in the viewer's mind, and there is educational value in bringing the concept to the center of cognitive activity. This activity is important in securing and enriching the memory of the conceptual system of the visual images. A person viewing the story-animation code is forced to draw a comparison between the *conceptual image* for the given concept that exists in his memory and the symbols in the broadcast. This comparative examination appears helpful in internalization of concepts. For example:

Red Blood Corpuscles



Globin, Hemo, & Globus



As the viewer of the documentary code adds to the treasury of *visual symbols* related to this conceptual system of the subject being viewed, his science imaging ability improves. While an individual who uses exclusively verbal channels of reading and hearing learns only certain facts about the circulatory system; someone who, on the other hand, views the same thing in a documentary broadcast hears the terms verbally and sees the scientific symbols. The viewer of the documentary code is provided with images for the red and white blood corpuscles, the heart, and the blood vessels. The symbols projected on the screen will be recalled as schemata or images and comprise the visual basis for the viewer's conceptual system of this subject. The theoretical foundations of these references are found in the fields of the psychology of learning and semiotics. Nevertheless, they warrant further research with the intention of focusing on the scientific concept, how it is received by the senses, and how it is stored in the memory.

Recommendations

Given that we live in the era of communication media, it is imperative that we give more thought to how technology influences learning. The results of this study support the conclusion that concepts in the sciences may be learned by means of unguided television viewing. The recommendations of this study are intended for policy makers in television broadcasting stations, writers, and producers of programs for the sciences and people involved in supervision, instruction, and research in the teaching of the sciences.

Broadcasting Policy and Production of Science Related Subjects

The screening of a large and varied number of television broadcasts in the sciences will encourage and intensify the acquisition of knowledge. Accordingly, the more television time alotted to the screening of broadcasts in the sciences, especially popular programs that incorporate scientific concepts, the more positive will be the attitudes of the viewers regarding the sciences, and the greater will be the knowledge gain about televised concepts among the viewing public.

Considering the immense popularity of the animated story code, it is highly recommended to continue producing television series in this code. However, consideration should be given to the correct interpretation of the symbol system of the medium of television.

Improving Production of Broadcasts in Sciences

Misconceptions, says Howard (1987), are the unavoidable results of the learning process. This was confirmed by our research into the two codes. In order to minimize, as much as possible, the formation of misconceptions resulting from the television viewing of broadcasts in biology and the sciences, special attention should be given to sensible production of these broadcasts. Since this medium is auto-didactic, the television screen itself can be used to guide the viewer in the direction of the desired outcome. It would be most advisable to implant in the broadcast itself an exact explanation of the concepts to be taught in both picture and sound. By incorporating such an explanation into the beginning of a broadcast, the explanation becomes the basis for continued viewing of the broadcast. Good broadcasts in the sciences targeted for viewing by children and teenagers do exist today, and they employ a mixture of several genres, in which discrete concepts are explained in a number of codes. The result is that

documentary film, acting, and animation merge and interact in the same broadcast.

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