Contents

1. Introduction **2**

2. "Don't Talk About it Show it": Positive Effects of Hypermedia Pictures on Children's Reading **4**

2.1 Memory 4
2.2 Comprehension 7
2.3 Motivation 11
2.4 Attention 12

3. A Picture Is not always Worth a Thousand Words: Factors to Be Taken into Consideration **13**

4. Conclusion **17**

Bibliography **19**

THE IMPACT IMAGES HAVE ON CHILDREN'S LEARNING IN A HYPERMEDIA ENVIRONMENT.

(Images: *Static, Animated, and Dynamic)*
(Learning: *Memory, Comprehension, Attention span, and Motivation)*

Marianthi Papadimitriou

1. Introduction

Critically viewing educational procedures, the prevalence of printed text and the marginalized role of pictures are quite noticeable. This dominant use of the written mode of language in the educational system might be attributed to several factors. Social and cultural issues might comprise one significant agent. According to Gardner, western cultures value most the importance of logical and mathematical abilities whereas spatial or musical abilities are considered inferior (as quoted in Wood, 1998). In addition, Kress (1998) argues that in western societies "writing is serious and most highly valued; [whilst] music is for the aesthetic development of the individual, as is visual art". Thus, what has come to constitute 'serious educational work' by both teachers and students and what is actually sanctioned by the formal school curriculum is reading and writing in its basic black and white form. Two more factors that might influence the multiplicity of representational and communicational modes in education would be that of economical and practical considerations. Fully illustrated and good quality color books increase educational expenses excessively. While the use of several media requires equipping every class with a TV, a video, a stereo and an overhead projector which is not economically feasible. On the other hand, even if all of the above equipment were at the disposal of every teacher, still a great deal of mental effort and time would be needed to combine the different sources in a meaningful and constructive way.

As far as the last considerations are concerned, the use of Hypermedia and Multimedia resources might play a vital role in increasing the potential utilization of several media in the educational process, taking into account two factors. Firstly, the accessibility of a computer in every class is a more reasonable economic target and the actual cost of the CD-ROM itself is negligible (Tagg, 1995). Secondly, Hypermedia could save valuable time in the preparation as well as in the presentation of the relevant material combining text, graphics, animation, pictures, video and sound in a very effective and professional way.

In such a multimodal electronic environment the visual display features form a very important component. Metaphors, graphics (icons, windows, dialog boxes), diagrams, video, animation and still images, all comprise modes of visual representation that could be categorized as pictures. In the present paper, the term pictures will refer mainly to still, moving and dynamic images as defined below. *Static Pictures* consist of what can be characterized as conventional images, namely pictorial material also available in the form of paper-based images such as photographs, illustrations in books and so on. While, *Animation* is produced by a series of static images that are shown in rapid succession in order to produce the illusion of movement. This effect depends on the fact that images formed on the human retina persist for some time after the source of the image has disappeared. Finally, an *Interactive Dynamic* is defined as an animated graphic which continuously changes depending on students input. In this sense, dynamic pictures are ‘reactive’ (they react when students click on them) (Rieber, 1990; Barker, 1989). For organizational reasons, in this paper the function of these three categories of pictures will be analyzed relatively separately, even though when pictures are synthesized for display they can of course utilize any combination of static, dynamic and moving components.

A number of points the essay in question will examine are the following:

- The possible pedagogic implications of a turn from a mainly text oriented organization of educational material to a pictorial delineation of knowledge.
- A comparison between the role electronic images (static, animated, dynamic) might play in the effective learning of children as opposed to conventional ones.
- Problems that might arise from the use of electronic pictures including proposals of possible solutions.

The age range that the essay refers to is mainly the early school years throughout elementary school.

2. "Don't Talk About it Show it": Positives Effects of Hypermedia Pictures on Children's Reading.

2.1 Memory

One of the earliest experimental studies on free recall was conducted by Kirkpatrick in 1894 (as quoted in Paivio, 1971). Since then studies on recognition and recall memory for pictures and words, in what is mainly called 'pair associated learning', has been the focus of much research. The bulk of the results of those studies has demonstrated the extremely large capacity and the considerable duration of recognition and recall memory for pictures. Even very young children's recognition memory for pictures is very good and improves with age (Shepard, 1967; Kobayashi, 1986; Pressley, 1977; Paivio, 1971). But to what could the superiority of pictorial memory be attributed?

Many researchers have tried to establish a reasonable answer to this question, though Paivio's 'dual coding theory' seems to be the most commonly accepted (Kobayashi, 1986; Ayershman, 1996). According to this theory, pictures and words activate independent imaginal

and verbal codes, and the availability of this dual code differs; that is a verbal code for a picture is more available than an imaginal code for a word (Kobayashi 1986). Thus, it is assumed that pictures are more likely to be redundantly encoded. According to Paivio (1971) it is this increased availability of both codes that increases the probability of item recall "for the response can be retrieved from either code -one code could be forgotten during the retention interval, but verbal recall would still be possible provided that the other is retained". This theory suggests that better learning takes place when both verbal and visual information is presented together (Szabo & Phookey, 1996).

Findings of other research on this area though, show that the use of pictures may not always facilitate learning. As far as the acquisition of a sight vocabulary is concerned, many children, especially young and poor students, seem to be unable to shift attention from the less salient but more relevant cue, from pictures to letters, when the visual and verbal stimuli is presented simultaneously (Willows, 1978; Samuels, 1970). In these cases, the principle of least effort tends to dominate; that is when a complex stimulus is presented to a subject, s/he will select that aspect of the total stimulus which most easily elicits the correct answer. Consequently the focus will be on the picture if the child finds difficulty in reading. In this case, of course, the child is performing picture recognition, not word recognition (Underwood, 1963 as cited in Samuels, 1970). Unfortunately, in a conventional print medium the linear way of representation, as well as spatial and economic considerations, necessitate the presentation of text and pictures at the same time. Thus, turning a page of an elementary school book may reveal both visual and textual stimuli. On the contrary, in a Hypermedia environment all difficult words may be hyperlinked to a picture or an animation that would explain their meaning without the above prohibitive considerations. The separate presentation of visual and textual elements of hyperlinked related pictures may contribute to children decoding the text more accurately and thus enhances children's recall ability (Willows, 1978a; Pressley, 1997).

As far as reading is concerned, Willows (1978a, b) indicated the potential interference between the messages provided by text and pictures. He argues that pictures may be used as prompts when the student cannot recognize the word in the text. But if a child does not know a particular word and refers to the image for a pictorial clue s/he might be misled by the elements of the visual representation that are not directly relevant to the word s/he is trying to decode. With linear textbooks, this is always a potential fear, as illustration and textual elements are presented simultaneously and most of the time in a quite complex way (many components of the text are included in a single picture, usually as a result of the restricted number of images). In opposition to that, in a Hypermedia environment it is possible, with control of the computer, to present the two codes separately. To be more specific, the visual element could be presented first, until a certain time has expired or instruction to focus on the message of the picture has been completed, and then the textual element could follow or vice versa. In this way a child can be presented with both codes, necessary for efficient memorization to take place, and still avoid to a certain extent interference problems.

Apart from Hypermedia's ability to display the two stimuli eterochronously, unique characteristics of electronic images, such as interactivity and motion, also play a very significant role in children's memorization. As many researchers stress, interaction and motor activity facilitate the construction of mental images which in turn facilitates memory (Pressley, 1977; Rieber, 1990b; Delclos & Hartman, 1993; Weyer, 1988). Dynamic pictures specifically, more than static, enable the user to be active in the task and give him/her a feeling of control over the system. Therefore, they are capable of cementing entire relationships firmly in memory (Stoney & Wild, 1998; Hooper, 1988). Animated pictures, on the other hand, may even change the way children recall a text. Mathew (1997) showed that hyperlinked moving pictorial representations enhance free recall, whilst static print text and unchanging illustrations facilitate the cued recall of information. That means that the constantly changing and non-linear

form of animated pictures in a Hypermedia environment may enable students to develop their ability in story retelling.

The hyperlinked way electronic pictures are organized might have a significant advantage of memory in comparison with static pictures. But do they have the same comprehensive value? As memorizing and comprehending are qualitatively two different activities, below, an analysis of whether and how images in the different media (linear and hypertextual) may function in different ways and affect differently the understanding of words, meanings and children's comprehension of texts will be attempted.

2.2 Comprehension

Researchers have recognized mental imagery as one of the primary mental structures for text comprehending and learning (Pressley, 1977; Paivio, 1971). They support that images are more likely to be meaningfully processed spontaneously than words for two reasons. Firstly, they have the ability to communicate some concepts more directly when text talks about it indirectly. Secondly, they are easier to process and more memorable. Therefore, comprehension, story production and decoding skills are enhanced by the use of pictures (Kress, 1996; Crawford, 1990; Laurel, 1990; Liebhold, 1990; Barker, 1989; Hooper, 1988; Kobayashi, 1986; Collins, 1997; Guttman, Levin & Pressley 1977; Ayersman, 1996). However, as children up to 9-10 do not automatically or spontaneously form mental images when reading and consequently rely more heavily on external pictures (Pressley, 1977; Paivio, 1971; Kobayashi, 1986) teachers should provide them with adequate visual elements to facilitate learning. But what kind of visual stimuli do student need and do pictures in both linear and Hypermedia environments contribute to the comprehension of words and texts?

As far as concrete picturable examples (e.g. chair, cat) are concerned, static pictures in both conventional media and Hypermedia may be equally effective in presenting a concept of a word and consequently, in assisting word comprehending (Reiber, 1990). What happens,

though, when more abstract and general ideas are introduced? What happens with concepts that cannot be depicted in a simple static picture and for which a verbal, dictionary type of explanation might not help children form internal mental images? Unlike a book format, in a Hypermedia environment pictures do not need to be static. Video and animated images form a substantial part of a Hypermedia presentation and they can provide a much more communicative and convincing display under particular circumstances. For example, they may prove very powerful in representing highly abstract words and concepts that do not have a readily apparent physical referent or counterpart (e.g. atom, blood flow). Additionally, moving images may provide a more direct and accessible means of communicating concepts like time, motion, trajectory and space (Szabo & Phookey, 1996; Rieber, 1989, 1990; Park, 1994; Laurel, 1990). They can also simplify complex processes as well as processes too dangerous, expensive or time consuming to take place in a real classroom (Tagg, 1995, Liebhold, 1990).

Apart from the ability of animated pictures to facilitate children's word comprehension, researches have shown that moving and dynamic pictures in comparison with conventional ones may increase reading comprehension as well. In particular, being a more direct means of communication, they allow children to spend more time concentrating on the comprehension task and on the meaning of the context rather on the decoding of difficult concepts. This may prove especially beneficial for low ability students (Rower & Matz, 1975; Frase, 1972, cited in Pressley, 1997). In addition to that, text comprehension may increase because moving images have the ability to provide opportunities to display the impossible and to offer an alternative view to the thoughts of a hero in a realistic way that static pictures cannot (Baecker & Small, 1990). To be more specific, animation may help to reinforce the point of the story in that inanimate objects can be injected with feeling and emotion, thus acquiring "animus" - life.

Another contribution of moving images to children's comprehension may lie in interactive dynamics. As opposed to print pictures, where interaction is one way, Hypermedia pictures can be responsive to students' input. When images are dynamically controlled by the user they might convey information in a much more meaningful way because dynamic manipulation of an image might turn children's attention to a stimulus. And the stimulus that is more likely to be attended is more likely to be 'deeply processed' and comprehended as well.

Furthermore, the advantage of juxtaposing documents (pictorial and textual) in a Hypermedia environment might significantly aid children's comprehension. Matthew (1997) points out that low achievers often experience difficulty combining information presented in several different parts of the text and images in order to "go beyond the information given". Therefore, the ability to move from text to pictures and from pictures to text may help them to achieve better on inference items because items as interlinked materials may increase the ability to discover links among people, places, events and issues within a particular context. Hypermedia pictures can thus make the importance of interrelationships of ideas more explicit to children and help them develop a clearer and more emphatic understanding (Hooper, 1988; Murray, 1994; Ayersman, 1996). Additionally, students can take advantage of the hyperlinked connection between text and pictures and become more critical of the kind of relationship that the visual and textual information may bear. In particular, children working with Hypermedia could quite easily compare an author's text and juxtaposed pictures in order to discuss on whether the author's opinion is supported by pictorial evidence or not. This juxtaposition of pictorial and verbal elements might enable students to discover and realize that pictures and text sometimes convey different messages. Therefore, they become aware of the need to be critical and attentive in their decoding of verbal and visual information or even challenge the reliability of a text (Laurillard, 1993; Ketch, 1990; Crane, 1991, as cited in Laurillard, 1993). In the case that visual and textual elements are not compatible a very fruitful educational activity

would be for children to electronically change the one or the other element according to their judgment so as to convey the same meaning and support their decision for doing so.

Moreover, with the possibilities that Hypermedia offer, pictures can easily be manipulated by children and become an integral part of the meaning making process (McMahon & O'Neil, 1993). In contrast to a static medium, electronic images can be scanned, cropped, copied and digitally altered. The particular ability to manipulate images seems to result in projects in which the visual elements are much more central than they are in more traditional projects and are used not only as an illustration but as a main supportive element of a Multimedia presentation (Tagg, 1995, Heppell, 1994). What is more, by digitally altering a picture, children may become aware that visual effects can be easily manipulated in such a way as to present a more convenient version of "truth".

The additional ability to produce animated pictures instead of still ones forms a very constructive procedure that might lead to deeper comprehension. As Nicol (1990) asserts with HyperCard, having the actual children create animated pictures and show the sequence in motion, as opposed merely talking about it, requires them to think very carefully about the order and synchronicity of events which contributes to a more profound and analytic comprehension. In any case, Hypermedia may give the opportunity to children to become image producers, not only consumers and even to recognize what Kress (1996) comments:

> "the meanings which can be realized in language and in visual communication overlap in part, that is, some things can be expressed both visually and verbally; and in part they diverge – some things can be 'said' only visually, others only verbally. But even when something can be 'said' both visually and verbally the way in which it will be said is different"

2.3 Motivation

It is generally accepted that in the educational context attractive pictures, printed or electronic, can be very motivating and may develop positive attitudes towards reading (Collins, 1997;

Murray, 1997; Stoney & Wild, 1998). Inherent characteristics though, of animated and interactive pictures, can prove even more motivating for children for several reasons.

A very important feature of Hypermedia pictures that contributes to an increase of children's motivation is motion. The expression "we do not live in a static world" is often used to describe the need for having moving pictures, an element taken for granted in our everyday life but missing from textbooks. Children from a very young age spend several hours viewing television (cartoons) and playing video games, thus they are quite used to and amused by animated images. According to Collins(1997), because it is a familiar and relaxing concept for children, animation lessens the tensions in learning and gives children a sense of playing. In one research she carried out on primary school pupils, she found that once students finished reading the texts and completing the comprehension assessments, children returned to the electronic texts to reread the stories and explore the illustrations. However, students were not interested in returning back to the text and illustrations after completing the assessments of the print texts. In accordance to that, Murray (1994) claims that animation, especially cartoon techniques, can be very motivating, have charisma and glamour. What is more, they are more economical for the computers memory and are therefore displayed more rapidly, a fact that contributes to the general excitement.

Apart from the element of motion, the ability to interact with electronic pictures can also increase intrinsic motivation. Interactive dynamics make the experience of reading more interesting and fun for children of a wide range of ages and abilities by introducing the notion of not only "learning by doing" but "learning by playing" as well (Jones & Liu, 1997; Collins, 1997; Stoney & Wild, 1998). In particular, the playful and amusing character of hot spots may enhance children's experience of reading the story and even encourage students to read beyond the text of a particular page (Collins, 1997).

Furthermore, animated and interactive images, in comparison to static ones, can radically increase the viewer's sense of reality and hence increase motivation. Murray (1997) gives a wonderful example of how moving images in a Multimedia environment can provide students with a very stimulating, strong and unique experience of space and time travel. In particular, he refers to the role that animation and interactive pictures play in surrogate travel, an imaginary journey which locates students physically in Paris. As he explains "a sequence of still images that mimic a walk through the area, give a sense to the user of being a pedestrian walking step by step to the roads of a particular place". This psychological immersion in a simulated reality is further increased by the existence of real photographed interactive objects that provide an element of surprise, such as a copy of Figaro that can be opened, a message machine that can be operated by clicking on its familiar buttons and a telephone on which one can dial numbers. Children may find such elements of surprise and the unexpected particularly motivating, elements strongly present in the use of animated dynamics.

2.4 Attention

Quite a common teacher complaint is that their students, in particular young ones, do not pay as much attention as they would like them to. It is true that children's attention does seem impulsive and brief compared with grown ups. One reason that young children are not able to concentrate for long periods of time like adults is that they have neither discovered and developed strategies such as rehearsal and organization of material to aid learning, nor are they as analytical and exhaustive in inspecting pictures as older children (Wood, 1998). The capability, though, of even very young children to pay attention to television is remarkable (Jones & Liu, 1997). It seems that moving pictures have some kind of inherent characteristics like playful motion and interactivity that attract the attention of the eye, characteristics that are missing from static pictures.

In this section there will be only a brief mention of the electronic images' characteristics that might increase children's attention, as there seems to be an overlap between those and the characteristics mentioned previously that contribute to children's increased motivation. According to researchers, young children pay attention to content that fits to their prior knowledge; thus animated pictures used in Hypermedia may gain the attention of even very young children (Rieber, 1990b; Mathew, 1997; Hakanson, 1990). In addition to that, moving images may increase the programs cosmetic appeal and maintain students interest by being lively and enjoyable (Baecker & Small, 1990). Moreover, the interactive capability of images in a Hypermedia environment may form another factor that contributes to the increase of a child's attention span, because when a student is actively engaged in a task it is more likely that s/he will stay on the task as well. The opportunities of being actively engaged with pictures in a print form are much more reduced. As Bandura asserts, it is worth to be quoted that "Although attention does not guarantee any memory or comprehension, attention is necessary for any memory and comprehension that does occur" (Bandura, 1977 as cited in Anderson & Lorch, 1983).

3. A Picture Is Not Always Worth a Thousand Words: Factors to be Taken Into Consideration

In the previous section the main aim of the essay was to present how the use of pictures in a Hypermedia environment may enhance children's learning in comparison, where possible, with pictures in a static medium. Bearing in mind, though, that "the debate about Multimedia design and application has been characterized by discussions about what is technologically possible rather that what is pedagogically desirable and in what context" (Heppell, 1994), the following section points out some of the problems that a bad or excessive use of pictures in a Hypermedia

environment may cause. Moreover a proposal on possible solutions from an educational point of view is made.

As mentioned above animated and dynamic pictures may increase students' interest and motivation. When badly used though, they can also be distracting and even inhibit learning by diverting the student's attention focus (Handler & Dana, 1998; Park, 1994). To be more specific, many researchers have noticed that with electronic media there is always the fear that a child left alone will play with the pictures rather than the words. As in the case of electronic stories which, without the teachers intervention, become computer games as students search for hot spots to activate (e.g. Matthew, 1997). Of course, the presence of pictures should enhance and motivate children to engage in reading and not encourage students to avoid it. Thus, careful monitoring and guidance by the teacher should take place to ensure that students do not become so distracted by the animations and sound effects that they fail to read and comprehend the textual element. Designers, on the other hand, should always bear in mind the distracting nature of animated pictures and be more thoughtful of how, where and when these pictures should be used in order to support and not distract from the educational procedure.

Another factor to be taken into account, is that the ease of creating pictures and animation in Hypermedia may often result in over complex or superfluous use of visual elements and effects which may not only be distracting but also very confusing and even cause cognitive overload (Park, 1994; Handler & Dana, 1998; Oren, 1990; Stoney & Wild, 1998; Willows, 1978). The issue of cognitive load and display density might be of prime importance when young children are concerned because of their more limited working memories. According to Wood (1998), children cannot hold as much in their minds as adults can when they think, because their speed of processing is slower. Therefore, educational software designers should both take into account student's limited ability to retain related pieces of information and control the amount of information presented on a single screen in low levels.

They should also consider that one picture balanced with the text may be more effective than several pictures in a crowded screen. Moreover, it would be useful for teachers to critically view a Hyper/Multimedia piece of software on the basis of visual display criteria (simplicity, clarity, balance and space) before its use for educational purposes. Additionally, evaluating a badly designed Hyper/Multimedia resource with students could also be a fruitful activity as in this way children may learn the importance of careful design in projects meant to communicate ideas to others.

Further, a design problem encountered with some structured Multimedia activities, such as question and answer practice, is bad use of visual feedback. Designers should be very careful when and how they use pictorial elements and in particular animation to provide feedback because in many Multimedia CD-ROMs the difference between the positive and negative feedback is hardly noticeable, making it difficult to separate the right from the wrong answer. In other cases, the negative feedback may be more exciting, attractive playful and funnier, inadvertently reinforcing the wrong responses.

An additional fear frequently expressed is that the ever present pictorial element in Hypermedia might take away children's imagination whilst electronic pictures, in particular animations, may quickly develop their own conventions and cliches, thus having little to add to an appreciation of the verbal element (Mackey, 1996; Collins, 1997). To the extent that students are spoon fed with ready made images, the risk of a flagging imagination and passive image consumption might grow. Hypermedia educational applications, therefore, should provide students with not only the ability to view text and pictures separately but also with a powerful tool to enable them incarnate their own mental images of the print on the screen and compare them with the ones originally existed in the Hypermedia program. Children's ingenuity might then counterbalance the use of visual cliches and conventions.

Last but not least, the danger that pictures may carry, shape and reproduce stereotypical images and ideas is increased in a Hypermedia environment, where the visual element is dominant and more powerful and the identity of the author may not be obvious. Teachers should bear in mind that Hypermedia images are not culturally neutral because those responsible for their production have made some choice, implicitly or explicitly, with regards to how and what they will present (Collins, 1997; Tagg, 1995). Thus, as children depend more than adults on pictures, educators should monitor very carefully the kind of ideas and concepts that are depicted - for example how well are different groups (e.g. women, black) and cultures (is the American culture dominant?) represented - and even draw children's attention to stereotypical features which could be analyzed and criticized. This activity aims at children developing a more critical view and understanding of the visual element, where it came from, who put it there, what purpose it serves and what misconception it creates.

Finally, it is important to stress two points. Firstly, although the above suggestions are presented in a quite separate way for both educators and educational software designers, the optimum target in the designing of any Hypermedia educational application should be for educators to combine efforts with instructional designers, computer programmers, and cognitive and educational psychologists to create software suited to their particular disciplinary needs and individual instructional approaches. Secondly, in a Multimedia environment pictorial elements play undoubtedly a very significant educational role but in no case do they function or exist in isolation from the remaining Hypermedia elements. In cooperation with sound and text they may create a very powerful combination. Thus, although the present essay focuses on how Hypermedia pictures affect children's learning, it is impossible to neatly extract isolated effects of visual elements from other Hypermedia components - nor is it desirable to do so.

4. Conclusion

According to Wood (1998) "attending, concentrating and memorizing are activities. Simply asking a child to pay attention will not work. The material to be remembered and learned must make sense to the child". Thus this essay aimed at showing how visual elements in a Hypermedia environment might make the educational procedure meaningful and contribute to the solution of some learning problems that arise from the use of conventional pictures in print. In particular, an analysis of how static as well as animated and dynamic pictures in a Hypermedia environment may constitute an auxiliary and supportive agent to children's memory, comprehension, attention and motivation was attempted. On the other hand, taking in account that Hypermedia were not purposefully designed for education (Whalley, 1993) and that designers may use electronic pictures more with the intention of impressing rather than teaching, the present paper points out some important factors in the use of Hypermedia images that might hinder the educational procedure, making suggestions at the same time as to how these obstacles might be overcome.

To conclude, it is worth highlighting the fact that children's ability to decode pictures is usually taken for granted. As Handler and Dana (1998) very accurately observe "Even though we are all consumers of images, nobody has taught us how to read and interpret them". Vast amount of researches though shows that children do not know how, or are unable or find it difficult to read static and moving pictures (Vurlipott, 1968; Mackworth & Bruner, 1970, as cited in Pressley, 1977; Rieber, 1989, 1990b). That is because "Implicit conventions like three dimensions, governing the interpretation of drawings and pictures are not natural nor automatic, they have to be learned" (Wood 1998). The ability, as well, to read relationships in pictures is experientially based, thus some experience with pictures is required to learn the rules of picture reading and to benefit from pictorial elaboration (Pressley, 1997). Considering the central role images play in our lives and the absence of any formal educational effort on students' visual

literacy, Kress (1998) correctly states that “in that sense education produces illiterates”. But, in a technological era like the present where Hypermedia do not comprise the future but the present, the educational system should ensure that students acquire the ability to attend to Hypermedia’s pictorial instruction appropriately. Children should learn to interpret electronic visual messages accurately and generally to develop strategies needed to utilize the specialized features of electronic pictures, realizing that: **“Ideas are not linear, neither are they necessarily expressible in words”** Bill Tagg (1995)

BIBLIOGRAPHY

Ambron, S., (1988), New Visions of Reality: Multimedia and Education. In Ambron, S., and Hooper, K., (eds.): Interactive Multimedia, Visions of Multimedia for Developers, Educators, & Information Providers. Redmond, Wash: Microsoft Press.

Ambron, S., (1990), Multimedia Composition: Is It Similar to Writing, Painting, and Composing Music? Or Is It Something Else Altogether? In: Ambron, S., and Hooper, K., (eds.): Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education. Redmond, Wash: Microsoft Press.

Ambron, S., and Hooper, K., (eds.) (1990), Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education. Redmond, Wash: Microsoft Press.

Anderson, D. R., and Lorch P. E., (1983), Looking at Television: Action or Reaction? In Bryant, J. and Anderson, D. R., (eds): Children's Understanding of Television: Research on Attention and Comprehension. New York: Academic Press.

Ayersman, J. D., (1996), Reviewing the Research on Hypermedia-Based Learning. *Journal of Research on Computing in Education. Vol.28, N.4, pp. 500-519.*

Baecker, R., and Small, I., (1990), Animation at the interface. In Laurel, B., (ed.): The Art of Human-Computer Interface design. Reading: Addison-Wesley.

Barker, P., (1989), Multi-Media CAL. In Barker, P., (ed.): Multi-Media Computer Assisted Learning. Kogan Page: Nichols Publishing.

Bickford, P., (1997), Interface Design: The Art of Developing the Easy-to-Use Software. Boston: AP Professional.

Collins, J., and Syred-Paul, A., (1997), Children as Researchers Using CD-ROM Encyclopedias. In Wegerif, R., and Scrimshaw, P., (eds.): Computers and Talk in the Primary Classroom. Clevedon: Multilingual Matters LTD.

Collins, J., Hammond, M., and Wellington, J., (1997), Teaching and Learning with Multimedia. London: Routledge.

Crawford, C., (1990), Lessons from Computer Game Design. In Laurel, B., (ed.): The Art of Human-Computer Interface Design. Reading, Mass: Addison-Wesley.

Delclos, R. V., and Hartman, A., (1993), The Impact of an Interactive Multimedia System on the Quality of Learning in Educational Psychology: An Exploratory study. *Journal of Computing in Childhood Education. Vol.26, N.1, pp.83-93.*

Foley, Walance and Chan (1989), The Human Factors of Computer Graphics Interaction Techniques. In Preece, J. and Hall, L., (eds.): Human-Computer interaction. Prentice Hall International.

Guttmann, J., Levin, R. J., and Pressley, M., (1977), Pictures, Partial Pictures and Young Children's Oral Prose Learning. *Journal of Educational Psychology. Vol.69, N.5, pp.473-480.*

Hakansson, J., (1990), Lessons Learned from Kids: One Developers Point of View. In: Laurel, B., (ed.): The Art of Human-Computer Interface Design. Reading, Mass: Addison-Wesley.

Hammond, N., (1993), Learning with Hypertext: Problems, Principles and Prospects. In McKnight, C., Dillon, A., and Richardson, J., (eds.): Hypertext: a Psychological Perspective. Chichester: Ellis Horwood.

Handler, G. M., and Dana S. A., (1998), Hypermedia as a Student Tool: A Guide for Teachers. Englewood: Libraries Unlimited, Inc.

Heppell, S., (1994), Multimedia and Learning: Normal children, normal lives and real change. In Underwood, J., (ed.): Computer Based Learning: Potential into Practice. London: David Futton.

Hooper, K., (1988), Summary: Ten themes. In: Ambron, sS., and Hooper, K., (eds.): Interactive Multimedia, Visions of Multimedia for Developers, Educators, & Information Providers. Redmond, Wash: Microsoft Press.

Howland, J., Laffey, J., and Espinosa, M., (1997), A Computing Experience to Motivate Children to Complex Performances. *Journal of Computing in Childhood Education. Vol.8, N.4, pp. 291-311.*

Ivers, S. K., and Barron, E. A., (1998), Multimedia Projects in Education: Designing, Producing and Assessing. Libraries Unlimited.

Jonassen, D., and Grabowsk, B., (1993), Individuals, Differences, and Learning. In: Jonassen, D., and Grabowsk, B., Handbook of Individual Differences: Learning and Instruction. Hillsdale, N.J., Hove: Lawrence Erlbanm.

Jones, M., and Liu, M., (1997), Introducing interactive Multimedia to Young Children: A case study of How Two-Year-Olds Interact with the technology. *Journal of Computing in Childhood Education. Vol.8, N.4, pp. 313-343.*

Kobayashi, S., (1986), Theoretical Issues Concerning Superiority of Pictures Over Words and Sentences in Memory. *Perceptual and Motor Skills. Vol.63, pp.783-792.*

Koetke, J. W., (1990), HyperCard: A Multimedia Interface. In: Ambron, S., and Hooper, K., (eds.): Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education.

Kozma, B. R., (1991), Learning With Media. *Review of Educational Research. Vol.61, N.2, pp.179-211.*

Kress, G., (1998), Visual and Verbal modes of representation in electronically mediated communication: the potentials of new forms of text. In: Snyder, I., (ed.) Page to Screen: Taking Literacy into the Electronic Era. London: Routledge.

Kress, G., and Van Leeuwen T., (1996), Reading Images: The Grammar of Visual Design. London: Routledge.

Laurel, B., (ed.) (1990), The Art of Human-Computer Interface Design. Reading, Mass: Addison-Wesley.

Laurillard, D., (1993), Rethinking University Teaching: a framework for the effective use of educational technology. London: Routledge.

Liao, Y. K., (1998), Effects of Hypermedia Versus Traditional Instruction on Students' Achievement: A Meta Analysis. *Journal of Research on Computing in Education. Vol.30, N.4, pp. 341-359.*

Liebhold, M., (1990), Hypermedia and Visual Literacy. In: Ambron, S., and Hooper, K., (eds.): Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education. Redmond, Wash: Microsoft Press.

Mathew, K., (1997), A Comparison of the Influence of Interactive CD-ROM Storybooks on Reading Comprehension. *Journal of Research on Computing in Education. Vol.29, N.3, pp. 263-273.*

McMahon, H., and O'Neil, B., (1993), A story about storying. In Monteith, M., (ed.): Computers and language. Oxford: Intellect.

Murray, H. J., (1994), Restructuring Space, Time, Story, and Text in Advanced Multimedia Learning Environments. In Barret, E., Sociomedia: Multimedia, Hypermedia and the Social construction of Knowledge. Cambridge: MIT Press.

Nicholls, C., Merker, S., Cordts, M., (1996), The Effect of Computer Animation on Students' Understanding of Microbiology. *Journal of Research and Computing in Education. Vol.28, N.3, pp. 359-372.*

Nicol, A., (1990), Children Using HyperCard. In: Ambron, S., and Hooper, K., (eds.): Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education. Redmond, Wash: Microsoft Press.

Oren, T., (1990), Cognitive Load. In Hypermedia: Designing for the Exploratory Learner. In: Ambron, S., and Hooper, K., (eds.): Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education. Redmond, Wash: Microsoft Press.

Paivio, A., (1971), Imagery and Verbal Processes. New York: Holt, Rinehart and Winston, Inc.

Park, O. C., (1994), Dynamic Visual Displays in Media-Based instruction. *Educational Technology. Vol.34, N.4, pp. 21-25.*

Preece, L., (ed.) (1993), A Guide to Usability; Human Factors in Computing. Reading: Addison-Wesley.

Pressley, M., (1977), Imagery and Children's Learning; Putting the Picture in Developmental Perspective. *Review of Educational Research. Vol.47, N.4, pp.585-622.*

Rieber, P. L., (1989), The Effects of Computer Animated Elaboration strategies and Practice on Factual and Application Learning in an Elementary Science Lesson. *Journal of Educational Computing Research. Vol.5, N.4, pp.431-444.*

Rieber, P. L., (1990), Animation in Computer-Based Instruction. *Educational Technology, Research and Development. Vol.38, N.1, pp.77-86.*

Rieber, P. L., Boyce, J. M., and Assad, C., (1990), The Effects of Computer Animation on Adult Learning and Retrieval Tasks. *Journal of Computer Based Instruction. Vol.17, N.2, pp.46-52.*

Samuels, J., S., (1970), Effects of Pictures on Learning to Read, comprehension and attitudes. *Review of Educational Research. Vol.40, N.3, pp.397-407.*

Shepard, N. R., (1967), Recognition Memory for Words, Sentences, and Pictures. *Journal of Verbal Learning and Verbal Behavior. Vol.6, pp.156-163.*

Shneiderman, B., (1992), Designing the User Interface; Strategies for Effective Human-Computer Interaction. Reading: Addison-Wesley.

Stoney, S., and Wild, M., (1998), Motivation and Interface Design: Maximizing learning opportunities. *Journal of Computer Assisted Learning. Vol.14, pp.40-50.*

Szabo, M., and Poohkay, B., (1996), An Experimental Study of Animation, Mathematics Achievement, and Attitude Toward Computer-Assisted Instruction. *Journal of Research on Computing in Education. Vol.28, N.3, pp. 391-401.*

Tagg, B., (1995), Multimedia. In Tagg, B., (ed.): Developing a whole school IT Policy. London: Pitman Publishing.

Weyer, S., (1988), Text Today, Multimedia Tomorrow: Planning an Audiovisual Data Base. In Ambron, S., and Hooper, K., (eds.): Interactive Multimedia, Visions of Multimedia for Developers, Educators, & Information Providers. Redmond, Wash: Microsoft Press.

Whalley, P., (1993), An Alternative Rhetoric for Hypertext. In McKnight, C., Dillons, A., and Richardson, J., (eds): Hypertext: A Psychological Perspective. Chichester: Ellis Horwood.

Willows, M. D., (1978a), Individual Differences in Destruction by Pictures in a Reading Situation. *Journal of Educational Psychology. Vol.70, N.5, pp.837-847.*

Willows, M. D., (1978b), A Picture Is Not Always Worth a Thousand Words: Pictures as Distractors in Reading. *Journal of Educational Psychology. Vol.70, N.2, pp.255-262.*

Wood, D., (1998): How Children Think and Learn. Oxford: Blackwell.