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THOUGHT, CULTURE & COGNITIVE MODELS

Piaget's theory has recently been criticized by Wartofsky (1983) for failing to adapt to new information and ideas in the field of cognitive development: there has been too much assimilation and not enough accommodation. This amounts to a criticism that the theory is no longer capable of growth. Wartofsky calls for a historical epistemology, rather than a genetic epistemology, because phylogenesis, in cognitive terms, can no longer be seen to be biologically fixed. It is historical, cultural and it continues. From this it follows that ontogenesis is not the socialization of child-thought to a fixed adult world, but to a changing world. Thus, Piaget cannot determine those universal and necessary features of the growth of knowledge, because this assumes a fixed species as the norm. What is needed, according to Wartofsky, is an evolutionary theory of the history of cognition. Implicit in this is the need for Piagetian theory to accommodate to new ideas and theories in order to develop and progress, and there is an implied criticism that this has not occurred.

Piagetian theory exerted a great influence on the early work of the American cognitive psychologist Jerome S. Bruner, following his visit to Geneva in 1956. However, Bruner has shown himself to be more receptive than his mentor to new ideas which have been in conflict with Piagetian theory. He has continued to admit his mistaken assumptions (Bruner, 1983) and press on with an evolving view of human development. Central to this is his use of the Lamarkian metaphor:

> Assume, for example, that man continues to adjust when he learns a language and certain ways of using tools. At that particular point evolution becomes Lamarkian in the sense of involving the passing on of acquired characteristics, not through the genes, but through the medium of culture. (Bruner, 1966a, p.101)

For Bruner culture is essential for humankind because it is a means of transmitting the accumulated knowledge of earlier generations. Each generation does not have to re-discover the past. It does, however, bring with it a certain vulnerability, in that it is reversible and may be forgotten as has happened in the Easter Islands and the Inca civilization of Peru.

Bruner's increasing emphasis on cultural aspects of cognition, and in particular the amplification of cognition afforded by language, began with his contact with the works of the Soviet psychologist Vygotsky, who viewed intelligence as the capacity to benefit from instruction, with language having a powerful developmental role.

However, Bruner is still probably best known for his summary of the Woods Hole conference convened in 1959 by the National Academy of Sciences. Thirty-five 'scientists, scholars and educators' discussed ways in which education in science could be improved in primary and secondary schools, and the report of their deliberations was 'The Process of Education.'

The Process of Education

Paul Goodman announced in the N.Y. Herald Tribune that 'The Process of Education' (1960) was a classic comparable in its philosophical centrality and humane concreteness to Dewey's essays on education.

Bruner set forth a strong argument favouring the idea of models in the head based on general understanding, from which hypotheses about the particular could be generated and then tested against experience. According to Bruner the great disciplines (maths, physics, history) are not so much repositories of knowledge, they are methods for the use of mind. They provide the structure that gives meaning to the particulars, and the object of education is to get as swiftly as possible to that structure - to penetrate a subject, not to cover it. This is done by spiraling into it: a first pass to get the intuitive sense of it, later passes over the same domain to go more deeply into it.

Bruner complained that relatively little work by American psychologists had been done on the manner in which students could be trained to grasp the underlying structure of complex knowledge. He mentioned the latest researches which demonstrated that 'massive general transfer can be achieved by appropriate learning.' These studies were concerned with learning designed to produce general understanding of the structure of a subject, and as an example he considers mathematics:

> .... algebra is a way of arranging knowns and unknowns in equations so that the unknonwns are made knowable. The three fundamentals involved in working with these equations are commutation, distribution, and association. Once a student grasps the ideas embodied by these three fundamentals, he is in a position to recognize wherein 'new' equations to be solved are not new at all, but variants on a familiar theme. (Bruner, 1960, p.7)

This reflected the emphasis from the cognitive revolution of the 1950's concerning the generativeness of knowledge: knowledge is not a store-house. Learning is most often figuring out how to use what is already known in order to go beyond what is currently being thought - and this involves knowing something structural about what is being contemplated - how it is put together. As Bruner says 'Knowing how something is put together is worth a 1,000 facts about it. It permits you to go beyond it.' (Bruner, 1983, p.183)

Perhaps the most controversial statement in the book was that any subject can be taught to anybody at any age in some form that is honest. Bruner has since complained that this is easy to take too literally; he was simply arguing that there are many intuitive notions in a range of subjects (calculus, the theory of evolution etc.) whose early grasp would help learning of the later, fully developed idea.

This hypothesis was based on three general ideas. From Piaget he took the idea that the child's understanding of any mathematical, scientific or moral idea would be framed by the level of intellectual operations that he had achieved. Lower levels of understanding are routes to higher-level ones. The lower level is not a degraded version of the higher one - each has a logic of its own.

In addition to the Piagetian perspective Bruner suggested that the act of learning appeared to consist of three simultaneous processes: acquisition of new information; transformation of information to make it fit new tasks; and evaluation or checking whether the manipulated information is adequate to the task.

Finally, there was the idea of the 'spiral curriculum'. A curriculum ought to be built around the great issues, principles, and values that a society sees as worthy of continual relevance for its members, according to Bruner, and he demonstrates how this may be applied to science:

> So too in science. If understanding of number, measure and probability is judged crucial in the pursuit of science, then instruction in these subjects should begin as intellectually honestly and as early as possible in a manner consistent with the child's forms of thought. Let the topics be developed and redeveloped in later grades. Thus, if most children are to take a tenth-grade unit in biology, need they approach the subject cold? Is it not possible, with a minimum of formal laboratory work if necessary, to introduce them to some of the major biological ideas earlier, in a spirit perhaps less exact and more intuitive. (Bruner, 1960, p.54)

These ideas reflected the intellectual ferment of the times, particularly the structuralist influences of Chomsky, Levi-Strauss and Piaget, and there were many different reactions to such ideas. In Russia the book tripped off a debate on the dogmatism of Russian education; in Italy it was used to attack the decaying formalism of the right and the utilitarian pragmatism of the left. In Japan it caught a wave of reform and became an emblem against traditional learning by rote.

Modes of Representation

Following on from the success of 'The Process of Education' Bruner became concerned with the techniques and technologies that aid growing human beings to represent in a manageable way the recurrent features of the complex world in which they live. He noted that the principal change in man during the past half-million years has been by linking himself with new external implementation systems rather than by any conspicuous change in morphology - 'evolution by prosthesis' as the anthropologist Weston La Barre put it. Bruner quoted Washburn and Howell (1960) as evidence for this:

> It would appear that the large size of the brain of certain hominids was a relatively late development and that the brain evolved due to new selection pressures after bipedalism and consequent upon the use of tools.... (the) size of brain has increased some three-fold subsequent to the use and manufacture of implements. (Washburne and Howell, 1960, p.49)

Bruner suggested that the 'implement' systems have been of three main kinds:

1) Amplifiers of human motor capacities (levers, wheels, cutting tools).
2) Amplifiers of human sensory capacities (primitive devices such as smoke signals and modern ones such as radar).
3) Amplifiers of human ratiocinative (logical thought) capacities (lan-

guage systems, explanatory theories).

He stated that these are conventionalized and transmitted by the culture, particularly the ratiocinative amplifiers, which involve symbol systems governed by rules that must be shared. He also suggested that there are three systems for processing information allowing human beings to construct what he calls 'models' of their worlds, which emerge in the developing child in the following order:

1) through action
2) through imagery
3) through symbols and language

These three modes of internal representation are termed:

1) through action
   ENACTIVE
2) through imagery
   ICONIC
3) through symbols and language
   SYMBOLIC

Initially, Bruner saw the enactive phase running from very early in life, with language being superimposed at around 18 months and imagery declining at the age of 6 or 7 years: first comes enactive, then iconic and finally symbolic forms of representation. Bruner acknowledges in his autobiography 'In Search Of Mind' (1983) that he fell into the Genevan trap of postulating a chronological straight jacket. He now feels that these modes are present throughout life and are partially translatable into one another.

Enactive Mode:

The enactive mode of representation is highly manipulative in character. It is knowing some aspect of reality without the use of imagery or words. Hence, it consists of representing past events through making appropriate motor responses. It consists mainly of knowing how to do something; it consists of a series of actions that are appropriate for achieving some result eg. sailing a boat, tying a knot, riding a bike.

Iconic Mode:

This is based on internal imagery. The knowledge is represented by a set of images that stand for the concept. Iconic representation depends upon visual or other sensory organisation and is principally defined by perceptual organisation and techniques for economically transforming perceptions. Although initially seen as fading from use in the child's cognitive apparatus at the age of 6 or 7 years, it is now recognized as an important element in the highest intellectual realms. Consider what Einstein had to say about his thought processes:

> The words or language, as they are written or spoken, do not seem to play any role in my mechanisms of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be voluntarily reproduced or combined.... The above mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in some secondary stage...
> (J. Hadamard, 1945)

We have a similar account of Kekule's discovery of the benzene ring in a dream:

> Again atoms were gamboling before my eyes. Smaller groups kept to the background. My mind's eye trained by repeated visions of a similar kind, now distinguished larger formations of various shapes.... everything in movement winding and turning like snakes. And look, what was that? One snake grabbed its own tail, and mockingly the shape whirled before my eyes. As if struck by lightning I awoke. (Anschutz, R., 1961, p.700)

And there are other examples, such as Watson and Crick's discovery of the DNA helix (J.D. Watson, 1968). Bruner is suggesting that images stand for perceptual events in the same way that a picture stands for the object pictured. In many circumstances such a representation of the world has many advantages, but, as we shall see, there are also disadvantages associated with predominantly iconic forms of representation.

Symbolic Mode:

Increasingly throughout life there is recourse to the symbolic mode of representation of thought. The emphasis here is that representation is based upon an abstract, arbitrary and flexible system of thought. It enables individuals to deal with what might be and what might not, and is a major tool in reflective thinking, though as we have seen not the only one. This mode is representative of a person's ability to consider propositions rather than objects (as we have seen in the stage of formal operations), to give concepts a hierarchical structure and to consider alternative possibilities in a combinatorial fashion.

Bruner gives the following example to distinguish between the three modes and to show how there is a natural progression from enactive through iconic to symbolic modes of thought:

> Any domain of knowledge (or any problem within that domain of knowledge) can be represented in three ways: by a set of actions appropriate for achieving a certain result (enactive representation); by a set of summary images or graphics that stand for a concept without defining it fully (iconic representation); and by a set of symbolic or logical propositions drawn from a symbolic system that is governed by rules or laws forming and transforming propositions (symbolic representation). The distinction can most conveniently be made concretely in terms of a balance beam.... A quite young child can plainly act on the 'principles' of a balance beam, and indicates that he can do so by being able to handle himself on a see-saw. He knows that to get his side down farther he has to move out farther from the centre. A somewhat older child can represent the balance beam to himself either by a model on which rings can be hung and balanced or by a drawing. The image of the balance beam can be varyingly refined, with fewer and fewer irrelevant details present, as in the typical diagrams in an introductory textbook in physics. Finally, a balance beam can be described in ordinary English, without diagrammatic aids, or it can be even better described mathematically by reference to Newton's Law of Moments in inertial physics. (Bruner, 1966b, p.45)

Dale (1969) found in Bruner's ideas a conceptual framework which related to the three main divisions of his 'Cone of Experience' in the fifth edition of 'Audio-visual Methods in Teaching.' He suggested that our experiences vary according to the degree in which they involve us physically or in thought. Some experiences call for a good deal of concrete, direct, immediate action in which we make full use of our senses and often our muscles as well. Observing something, however, requires less physical, or concrete, action than an experience of doing. And symbolic experiences have virtually all the manifest physical action removed. Dale agreed with Bruner that we begin our learning of a specific matter with a broad base of direct experience in action and gradually we omit these specific, first-hand, concrete occurrences and impressions as we come to rely on iconic substitutes or pictorial representations. At both stages, we develop a summarizing idea or symbol and when we understand a symbol we can use a word or formula to stand for everything out of which it developed.

> This visual analogy (the Cone of Experience) is one of several devices that have been set up to show the progression of learning experiences from direct, first-hand participation to pictorial representation and on to purely abstract, symbolic expression.... the threefold arrangement of learning possibilities illustrates the three kinds of experience that we have found so important in the process of complete communication. In this respect it is similar to the analysis of the three major modes of learning made by Jerome Bruner. (Dale, 1969, p.108)

Thought, Language and the Zone of Proximal Development

Bruner went on to develop his curriculum package 'Man: A Course Of Study', which was concerned with the nature of man as a species, and the forces that shape his humanity. Five great humanizing forces, each closely associated with man's evolution as a species, were explored (Bruner, 1966b). These were tool making, language, social organization, the management of man's prolonged childhood and man's urge to explain his world and they reflected Bruner's increasing interest in Vygotsky's functionalist psychology.

Vygotsky was a Russian Jew, deeply interested in the arts and in language, and was a friend of the film-maker Eisenstein. His objective was to explore how human society provided instruments to aid the developing individual mind, and how the child clumsily takes over the forms and tools of the culture and then learns to use them appropriately. His functionalist psychology was interested in studying how the child uses hints and takes advantage of others helping him organize his thought processes until he can do so on his own. Vygotsky (1962) used the term 'Zone of Proximal Development' to describe the child's potential to use the help of others to gain consciousness and reach higher ground intellectually, transforming the meaning of the lower order concepts. Intelligence tests were inadequate measures of a child's ability, as far as Vygotsky was concerned, because they only show what she is capable of on her own. In the real world children have access to older children and adults to help them solve their problems, and so he argued that we should take into account the capacity of a child to profit from help that others can give when assessing a child's potential. The more they take advantage of an adult's support, the wider is their 'Zone of Proximal Development.' Two children may both be at the same stage when measured by conventional tests but may differ in the extent of their respective zones. With help one may manage to complete tasks usually completed independently by children four years her senior, whereas the other with similar help may only manage to extend his competence by two years, the limit of his zone. Of course, Vygotsky was writing at a time when advanced technological aids,in the form of calculators and computers, were not available to children, but there is no reason why the concept of a zone of proximal development should not be extended to include help derived from such powerful aids.

Vygotsky, working with Luria in the 1920's and early 1930's, offered a challenge to the prevailing Soviet view of psychology, which was predominantly a Pavlovian atomistic view, based on the reflex. They placed much greater emphasis on the transforming power of language and the internalized linguistic system represented in thought. Vygotsky's genius was to exploit the distinction between classical conditioning prior to the growth of symbolic function, and thought after the intrusion of what Pavlov reluctantly termed the 'second signal system.'

He suggested that symbol systems restructure mental activity, and as symbol systems emerge in the course of history so different cognitions will be produced. Basic psychological processes (abstraction, generalization, inference) are universal and common to all humankind, but their functional organization will vary depending on the nature of the symbol systems available in different epochs. Language is a universal symbol system playing a crucial role in the development of higher psychological processes. Other symbol systems which are not universal introduce culture-specific differences. Luria (1976) led an expedition in the 1930's to test Vygotsky's theory and found that there were consitent differences between traditional non-literate farmers and other members of the same villages who had undergone brief literacy programmes. The most traditional and isolated populations with neither literacy nor schooling were context-bound, guided by perceptual and functional attributes and responded in a concrete manner to the tests. The most schooled group were able to respond in a more abstract manner and were more responsive to the conceptual and logical relationships between things. This certainly pointed to confirmation of Vygotsky's thesis that socio-cultural changes form the basis for the development of higher psychological processes, and literacy could be used as an indicator of the level of functioning. However, there were many comensurate changes at that time within Soviet society and differences in mental operations could not be attributed to literacy or schooling per se (Scribner and Cole, 1981).

This line of research has been pursued by Greenfield and Bruner (1966) who found similar results with Wolof children in Senegal. Greenfield has suggested that the differences are due to the school children's capacity for context-independent, abstract thought, and has provided a link between this and written language. Olson (1976) has also supported the theory that literacy biases cultures toward the development of formal reasoning systems. Scribner and Cole (1981) disagree having found no evidence to support the construct of a general 'literacy' phenomena. They suggest that literacies are highly differentiated and that the Arabic and Vai scripts studied did not trade off for each other in predicting cognitive performance, nor do they (singly or in combination) substitute for English literacy. Their results suggest a more general effect of the de-contextualization prevalent in the culture of Western schooling, as proposed by Donaldson (1978).

Cognition and Culture

Piaget always resisted the idea that there is a psychological reality to culture that exists in the Popperian World 3 sense such that it can be internalized and serve as a prosthesis for the mind and development (Bruner, 1983), but for Bruner it became a crucial element in the child's development.

Bruner sees a person's maturing cognitive growth as being characterized by the increasing independence of his responses from the immediate nature of the stimuli and this growth depends upon the person internalizing events into a storage system that corresponds to aspects of the environment, by means of images, words, symbols. Through growth a person gains freedom from stimulus-control through mediating processes that transform the stimulus prior to the response.

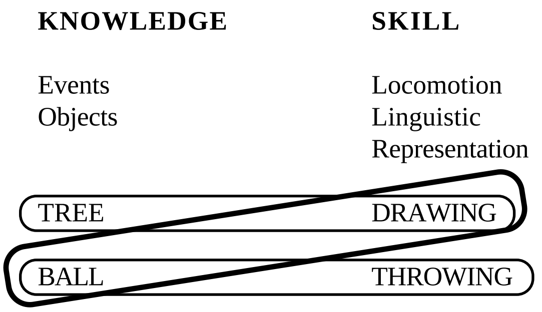
Although Bruner sees mental growth as being like a staircase with rather sharp risers - a matter of spurts and rests, the spurts being touched off when capacities begin to develop, he differs from Piaget in that he believes that the steps or spurts are not very clearly linked to age; some environments can slow the sequence down or bring it to a halt, others move it along faster.

For example, Bruner anticipates improvement in performance in Piaget's conservation task when the environment is changed, forcing the child to activate language and take advantage of the 'remoteness of reference' that is a feature of language. In such a situation the child is forced to say his description of the world in the absence of the things to be described.

This was confirmed in Franks' perceptual shield experiment, reported in 'Studies in Cognitive Growth' (Bruner et al., 1966). Children who were not 'conservers' were shown two beakers of different dimensions, one containing liquid. A screen was placed in front of the beakers and the liquid poured from one to the other. The child was then asked 'Is there still the same amount of liquid?' In the traditional Piagetian conservation experiment children observe the pouring of the liquid from one beaker to the other and when asked if there is still the same amount of liquid they focus on the changed appearance and indicate that there is more or less depending on the dimensions of the beaker. Franks found that many children who failed on the traditional test were able to answer correctly with the shield in place. Correct responses jumped from 0% to 40% for the 4 year-old group, from 20% to 90% for 5 year-olds, and from 50% to 100% for 6 year-olds. The most common responses being 'its the same water' or 'you only poured it!' When the screen was removed all the 4-year-olds change their minds, the perceptual display overwhelmed them, but virtually all the 5-year-olds held to their judgements, often invoking the difference between appearance and reality in their defence: 'It looks like more to drink, but it is only the same because it is the same water and it was only poured from there to there.' All 6 and 7-year-olds also held to their judgement.

When a post-test was administered with a different set of test materials to those used in the experiment it was found that in most cases the change in the child's reason-

Figure 7-1. The Relationship between Knowledge and Skills.



ing had generalized and it was concluded that it was attributable to the powerful organizing effects of language.

The experiment reflects Bruner's view that language is a powerful ratiocinative technology which provides the child with a qualitatively different model of the world to that based purely on observation and this enables the child to predict the outcome of manipulations of the environment more accurately. Such technological advances, in a cognitive sense, promote the development of intellectual functioning, according to Bruner:

> I shall take the view in what follows that the development of human intellectual functioning from infancy to such perfection as it may reach is shaped by a series of technological advances in the use of mind. Growth depends upon the mastery of techniques and cannot be understood without reference to such mastery. These techniques.... are skills transmitted with varying efficiency and success by the culture, language being a prime example. (Bruner, 1964, p.1)

Direct and Mediated Experience

Bruner's continuing interest in the interaction between cognition and the technologies of culture led him to consider the nature of experiences which are transformed and contribute to a person's internal model of the world.

He dealt with the various forms of direct and mediated experience in the 73rd Year Book of the National Society for the Study of Education under the title 'Learning Through Experience and Learning Through Media' (Olson and Bruner, 1974). These major aspects of learning, including the three modes of internal representation, are considered in terms of their partial equivalence and substitutability, and also their differing potential roles in the intellectual development and acculturation of children.

When discussing direct experience he suggests that organisms have commerce with the environment on their own terms and actively select those features which are necessary for the construction of representations of the environment which enable survival of the individual or species. From this it follows that 'our conception of physical reality is itself achieved by selective mediation' and it is the activities engaged in which determine the nature of such models of reality, as was suggested by Piaget (1971, Biology and Knowledge). Thus, we have a picture of reality that is biased or coded in terms of our actions upon it. Knowledge is always mediated or specified through some form of human activity and, according to Bruner and Olson, this activity has two facets:

1) Information about the world (knowledge)
2) Information about the activity used in gaining knowledge (skill, ability).

Further, it is suggested that there are two types of invariants that are specified through experience. Those features that are more or less invariant across different activities constitute our knowledge about those objects or events; the invariants across different objects or events constitute the basis of skills and abilities (Figure 7-1).

Within this context, Bruner claims that the goal or end-point is crucial in influencing the type of information to be sought and also the skills to be used in obtaining that information. He gives as an example the goal of 'learning about a country' and relates this to learning through direct experience:

> The most obvious way to learn about a country (the goal, or end-point) is to walk its streets, read its poets, eat its foods, work in its fields and so on. In so doing, one will learn both about the country (that the country is poor or hilly, etc.) and how to proceed in the activities required to be of that country (how to mend a net or tell a story). This is surely what is meant by learning through one's own direct contingent experience. (Olson and Bruner, 1974, p.130)

Vicarious Experience: Observational Learning

But there are other ways to acquire information eg. from seeing a person struggling with a load one can estimate its weight. In other words, one can experience vicariously and this facility opens up the pathways for learning from a variety of media: films and television, print and the spoken word. Such learning can occur when neither of the primary conditions for learning through contingent experience (self-initiated action or knowledge of its results) is fulfilled.

Bandura (1971) has summarized a wide range of data showing that behaviour can be changed by exposing the learner to modeling stimuli. In his classic ‘Bobo doll’ experiment (Bandura, 1965) children saw an inflatable plastic clown being abused in a television programme and were then allowed to play with a similar doll. The children were observed to copy the violent acts. Similar work has shown that altruistic behaviour can also be induced by observation of modelled behaviour.

Although early animal studies indicated that learning by observation was confined to higher mammals (Thorndike, 1898) later work has shown this not to be the case. Herbert and Harsh (1944), for example, had two groups of cats learn to pull strings and open doors by observing other cats. One group saw the final error-free performance, the other group saw early error-filled performance. Both groups of cats learned more quickly than the control group, which had not observed another cat’s performance.

Bruner (1972) notes that while all animals learn from contingent experience, primates are distinctive in their capacity for learning by observation - there being an enormous amount of observation of adult behaviour by the young. He places great emphasis on the potential of observational learning and particularly the relaxed atmosphere of the social units of the great apes which allow the young to spend extensive periods of time observing techniques, particularly tool-using behaviour, and practising and experimenting with the component acts.

Zimmerman (1977) claims that Bandura’s ‘Social Learning Theory’ (SLT) represents the most sophisticated formulation for human vicarious learning, in that it represents the ‘wedding between behavioural and informational processing explanations for human functioning’ (p.42). According to SLT observational learning is primarily a cognitive, representational process in which the representations are mentally transformed, stored either symbolically or iconically, and retrieved before being manifested as imitation. Zimmerman argues that it is possible for teachers to use observational learning principles, as described by Bandura, to organize classroom demonstrations to teach concepts and abstract skills to children.

Bruner agrees and indicates that when observational learning is used as an instructional technique in the form of demonstrations the child should be shown critical alternatives and how to choose between them (Olson and Bruner, 1974). Good instruction through modeling depends upon the sensitivity of the instructor to the alternatives likely to be entertained by the child. And, just as providing clear demonstrations involves skill, so it seems probable that learning from demonstrations demands a skill. Modeling may well depend on the capacity not so much to imitate directly as to construct behaviour from already mastered constituent acts in order to match selected features of the model. As an instructional technique modeling in the form of a demonstration is different from a skilled performance.

Vicarious Experience: Symbolic Learning

Bruner acknowledges that a further alternative to learning from direct experience is through symbolically coded information: words, diagrams, maps etc. It is learning through these symbolic systems that most readily substitutes for direct experience in formal schooling. Bruner and Vygotsky have both emphasised the extent to which language provides the means, par excellence, for teaching and learning out of context. Language provides an opportunity for acquiring knowledge in a form compatible with the rules of abstract thought. The human species is marked by its reliance on symbolically coded experience, so much so that language is taken as the distinctive human characteristic, and the development of literacy in various symbolic codes is the primary concern of formalized schooling. The major limitation of all cultural media such as language, numbers, graphs, diagrams etc, is that the information is conveyed through a symbolic system that places a high demand upon literacy in that medium. And the meaning extracted from those symbolic systems will be limited to the meaning acquired by the use of the symbol in the referential or experiential world. In other words, the major limitation of language is that no new information can be conveyed through language - if information falls outside the listener’s competence the sentence will be interpreted in terms of knowledge already possessed. Thus, instruction through language is limited to rearranging, ordering and differentiating knowledge or information that the listener has available from other sources (modeling, direct experience). Bruner makes the analogy here with the impossibility of verbally explaining perspective to the blind!

These different forms of experiencing a concept are seen by Bruner as being mapped on to a common underlying structure, or a coherent and generalized concept of reality and the very fact that the representations of reality are partially translatable, one to another, makes instruction possible. Thus, information relevant to action can be acquired by means other than direct action, so that we may learn to sail through watching films and reading books. But the three different forms of experience (enactive, iconic and symbolic) differ greatly in terms of the skills they assume and develop in the learner.

Forms of Instruction

Finally, Bruner suggests that there are three basic forms of instruction all of which provide information relevant to the acquisition of both knowledge and skills and these, in turn, are related to a variety of technological realizations:

1) Systems of arranged contingent experience which are related to structured environments for learning, such as laboratories and experiments, simulations and even educational toys.

2) Systems of observational learning which are associated with demonstrations and modeling, which may be live demonstrations or recordings on film or videotape.

3) Symbolic systems which include such technological realizations as print, drawings, diagrams, graphs and maps.

Thus, Bruner has related our interactions with the world, in terms of the forms of mediation, to the forms of representation which allow our construction of models of the world. These in turn have been related to technological realizations and the development of skills associated with the decoding of communications.

Olson (1976) has taken this further with his theory of instructional means. He makes a distinction between ‘utterance’ and ‘text’, in which oral language is characterized as ‘a flexible, unspecialized, all-purpose instrument with a low degree of conventionalization’ in which meanings are dependent on social relations, context and prior world knowledge of the participants. Written language, with its demands for explicitness of meaning, its permanence and its logical function, serves the cultivation of analytic, scientific and philosophical knowledge. Olson claims that there is a literacy bias in schools because ‘school intelligence’ is skill in the medium of text. Clark and Salomon (1986) indicate that such considerations lead to hypotheses concerning further cognitive effects of media which may lead to new ‘literacy biases’ succeeding older ones, for example, as may be the case with computer programming which is a highly structured and analytic activity in a rigidly constrained symbol system.

Cognition, Learning and Media

Salomon (1979) has extended these ideas in his exploration of how symbolic forms cultivate mental skills and affect knowledge acquisition. This acquisition is seen as being mediated by skills of information reception and processing, and because these skills are affected by the nature of the symbol system associated with a given medium, he suggests that each medium may have its own specific effects on how knowledge is extracted.

Salomon takes Olson and Bruner’s (1974) ‘sought after end’ and expands the idea as the ‘task to be performed.’ He argues that the perception of the task to be performed determines the kind of information one wishes to extract from a coded message. Learning can thus be facilitated to the extent that the activated skills are relevant to the demands of the learning task. He gives as an example a task calling for analytic comparison which activates imagery instead, leading to debilitated learning. Clearly, for effective communication there must be a match between the cognitive demands of the task, the skills required by the codes of the message and the learner’s mastery of the codes. There is some evidence which indicates that when certain skills are deficient switching instruction to a medium which places reliance on more highly developed skills or which compensates for the deficiency will enable information to be more readily assimilated.

To demonstrate this Salomon prepared several different versions of a film, which he reasoned would make different demands on the skills available to his fifth-grade subjects. Two versions were produced that were identical except for the fact that the shifts from long-shots to close-ups were accomplished by zoom-ins and outs in the Z version but were left out in the CU version. The Z version was designed to supplant the mental skills of connecting parts and wholes, which the CU version was expected to call upon. Prior to viewing the films the subjects were given a battery of mental tests, including a Detail and Whole Test in which a detail of a drawing was presented alongside the whole object to measure the ability to relate details to perceptual wholes, especially important in the CU version. The results indicated that:

> This difference between the Close-Up/ Long-Shot (CU) and ZOOM (Z) correlational patterns strongly suports the expectation that element-specific skill-mastery is required for the acquisition of specific knowledge to the extent that the coding element deviates from the viewer’s anticipatory schemata. Indeed, the Close-Up/ Long-Shot version seems to call on specific skills, whereas the Zoom version overtly supplants them. Hence, intitial mastery of the relevant skills is far less necessary for knowledge acquistion from the Zoom version. (Salomon, 1979, p.102)

This relates directly to Olson and Bruner’s (1974) assertion that knowledge is always mediated through some form of human activity, and the knowledge acquired through such activity has two facets: knowledge about the world and knowledge about the skills involved in gaining the knowledge.

Salomon also found that, at the time that television was being introduced to Israel, heavy viewers of the only children’s tv programme (Sesame Street) did better on the Changing Points of View Test. He reasoned from this that a technique which is all pervasive in film and television is the showing of the same scene from different camera angles and repeated exposure to these changes in physical points of view develops skill in shifting points of view in the mind.

A similar effect was observed with Salomon's Space Construction Test. The task is to put four pieces of a picture together so that they form a room. Children who did well on this test were also found to be better able to understand edited films. Salomon reasoned that this is because of visual techniques that are intrinsic to film and television. Three-dimensional space is divided up by pans or cuts in films rather than revealing the whole in one shot. To have a sense of the whole the viewer must mentally integrate the various elements, and commerce with this form of coding information develops the necessary cognitve skill, which enables information to be extracted from the communication.

Implicit in this reasoning is the idea that the symbol system associated with a given medium may produce cognitive changes which result in the cultivation of certain mental skills. Salomon suggests that this is the case with language, which appears to prime cognitive operations, even to trigger them. This receives support from Vygotsky (1962), and Luria (1978) and is in line with Bruner, Olver and Greenfield's (1966) claim that amplifiers of human capacities must produce an appropriate internal counterpart to be effective. Language is not, however, the only symbol system which participates in cognition and Salomon indicates that it should be possible to learn to think in graphic codes and he quotes the work of Hatano, Miyake and Binks (1977) which shows that expert abacus users internalize the operations of the abacus. Intermediate users still use visible finger movements to accompany mental calculations and if prevented from doing so their performance is impeded. Here the finger movements would appear to have a similar function to Vygotsky's egocentric speech, which is also on route to becoming totally internalized.

If symbol systems of media are to cultivate mental skills, as Salomon suggests, what are the psychological mechanisms involved? He indicates three ways in which cognition can be affected: (1) activation of skills that transform external codes into internal ones (2) short-circuiting skills by overtly providing the end result of mental tranformations that the learner should have employed and (3) overt supplantation, or modeling, of transformational procedures. Each of these have been shown to have a different effect on skill facilitation (Salomon, 1979). Coding elements that activate skills facilitate skill-mastery in already skillful learners; coding elements that short-circuit skills will have little cultivating effects; and coding elements that overtly model skills facilitate skill-mastery in intially unskillful learners.

Although Salomon's work has investigated symbolic codes in film and television, other media have also been shown to develop skills which are transferable. Gagnon (1985) found that giving Harvard College students 5 hours of arcade-game play improved their performance on a standardized paper-and-pencil test of visual-spatial ability, the games serving something like a remedial function for people with relatively undeveloped spatial skills. Greenfield (1987) has also demonstrated a carry-over from video game practice to tests which involved scientific-technical thinking, although novices, with only 2.5 hours practice, performed on the transfer task as well as expert games players with hundreds of hours practice. It has also been suggested that in learning to programme computers pupils will acquire powerfully general higher cognitive skills such as planning abilities, problem-solving heuristics, and 'reflectiveness on the revisionary character of the problem solving process itself.' However, Pea and Kurland (1984) caution against too much optimism and indicate that this is an old idea in a new form: similar arguments have been offered in centuries past for the beneficial cognitive consequences of other powerful symbolic systems, including mathematics, logic, writing systems and even Latin!

A New Direction for Educational Technology

Fosnot (1984) suggested that for most of its history, educational technology has attempted to justify and verify its own basic assumption that both the processes of technology and the products of technology can help improve instructional effectiveness. This has led to a systems approach to instructional design which is grounded in empiricism. However, educational technology need not remain in this position and Fosnot calls for educational technologists to come to terms with the new ideas in cognitive psychology, particularly those of constructivist psychology. Winn (1982) expresses a similar concern with instructional technology and concludes that research in cognitive psychology is further ahead than the application of research findings in instructional design. For many years the work of Piaget and Bruner, the very foundations of much exciting thinking in cognitive psychology, has been largely ignored in the field of educational technology. Now, thanks to the pioneering drive of such researchers as Papert and Salomon the new educational technology is inextricably linked to the 'booming, buzzing' world of cognitive psychology.

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