An, as yet, incomplete paper on Learning, and the impact of recent research on how the brain learns.

In writing this I am greatly indebted to the various researchers whose work I have here attempted to summarise. I am particularly indebted to Ray Dalton for his wise guidance in how to interpret such a growing body of significant, if sometimes rather dense, material.

A J Abbott
4 July 1992
"Our schools....... are not ineffective because they do not know what happens at synapses, or the chemistry of neurotransmitters, but rather because they have yet to address the brain as the organ of learning, and to fit instruction and environment to the "shape" of the brain as it is now increasingly well understood. We know that as a consequence of long evolution, the brain has modes of operations that are natural, effortless, effective in utilising the tremendous power of this amazing instrument. Coerced to operate in other ways, it functions as a rule reluctantly, slowly and with abundant error."

Leslie Hart
"Human Brain, Human Learning" 1983

"I'm optimistic that we - and here I mean to encompass educators from around the globe - can re-configure our educational environments and alter our pedagogic approaches so that many more students will attain a significant degree of understanding across a wide range of subjects. The key, I believe, is to devise learning environments in which the students naturally come to draw upon their earlier ways of knowing and to configure those environments so that students can integrate these earlier forms of knowing with the formats of knowledge that are necessary and appropriately featured in school."

Howard Gardner
"The Unschooled Mind" 1991
PAPER ON LEARNING

PREFACE

This Paper has been written especially for those working within Education 2000 Projects and others who contribute to our work in many different ways. It attempts to give an overview of the issues which have to be faced in bringing about the shift within education commonly referred to as "from Teaching to Learning". The phrase has now become almost accepted wisdom, without always a full appreciation of what its consequences are likely to be. Historically we have learnt much about teaching; the shelves of libraries are full of volumes on its art and practice. But what is involved in learning is something which has, perforce, been largely speculative until now. Only the most recent advances in neurological science have started to open up systematically a study of cognitive processes.

This is not an academic discussion; that has to be the subject of a much longer and bolder survey on which Education 2000 now has to embark. This Paper deliberately seeks to draw together contemporary understandings from many different sources, and to interpret these in ways which practitioners - teachers, parents, community figures and learners themselves - will find helpful.

It is not a matter of mere coincidence that the need to empower young people to learn how to learn is occurring at the same time as neurology and research on artificial intelligence are providing a far more precise understanding of the wonders that the brain can perform naturally, and its remarkable ability "to shut itself off" from inappropriately structured environments.

Education 2000 sees part of its role to bring these emerging insights on learning to the assistance of education as society struggles towards a new understanding of an education system appropriate to the needs of the 21st Century.
INTRODUCTION

Learning..... and the need to empower young people to use continuous learning as a means of transformation (how do we turn the present constraints into opportunities?)..... is at the very heart of Education 2000's work.

Everyone "knows" about learning; everyone has their own experience to draw upon, and their own favourite anecdotes. Our culture currently assigns an overriding significance to the role of the school as the place where real learning takes place, and to the sub-divisions of knowledge into a set of "disciplines". Earlier theories about the brain produced persuasive evidence of a mechanistic process to explain how learning occurred and of the existence of a quality called "intelligence" which it was thought could be measured, and was largely predetermined genetically. It was assumed to be indicative of certain kinds of future achievement, and to provide limits to what the majority of people could learn.

Most thinking people now realise that these stereotypes are suspect.. Single definitions of intelligence do no credit to the wide-range of achievements that have little, if any, correlation to a general factor of intelligence. Some "school refusers" have gone on to be outstandingly successful members of society. Enormous numbers of us experience real discontinuities between what we seem to learn naturally and that which we have to learn mechanically. Increasingly people question whether the sub-divisions of the curriculum, so beloved of specialists, are not counter-productive of real understanding.

So powerful are the assumptions about learning - "I'm thick, and I can't learn"; "School said I was a failure, but I know that was unfair"; "He's a swot, and not to be trusted"; "She really knows what she's talking about"; "You can't teach me anything" - that the basic tenet that man is essentially a Learning Species comes as a shock to many.
"We underrate our brains and our intelligence. Formal Education has become such a complicated, self-conscious and overrated activity that learning is widely regarded as something difficult that the brain would rather not do..... but reluctance to learn cannot be attributed to the brain. Learning is the brain's primary function, its constant concern, and we become restless and frustrated if there is no learning to be done. We are all capable of huge and unsuspected learning accomplishments without effort".

(Frank Smith "Insult to Intelligence" 1986)

Young children of pre-school age, learn extremely rapidly of their own volition; those living in stimulating and exciting homes make quite extraordinary progress by the age of 5. Their "natural curiosity" seems to disappear as they move into formal schooling...... some come to terms with this, and do well; too many others never recover that natural curiosity and become "restless and frustrated" not because there is no learning to do, but because they can't make a connection between their needs and a system that seems alien.

While it is man's ability to learn that has enabled him to evolve to his current position of near mastery of his planet, we sense that the process of learning in schools is becoming confused, and for many people breaking down completely. "The Crisis in our Schools" could be a headline in a paper today in America, Australia or the United Kingdom; signs are that it will soon be so also in countries as self-assured as Germany and Japan. The "Crisis in Learning" is fast becoming an international phenomenon. Frankly, schools as conventionally structured are just not working.

Education 2000 believes that a reappraisal of how learning takes place within contemporary society is an essential first step in preparing to provide richer and more challenging learning environments which will enable ever more people to "make a connection" between their natural curiosity and the mechanisms to extend their learning in ways which are significant and meaningful.
LEARNING

Learning is the prime function of the brain. It is the ability of the individual brain to select what it deems to be significant information and then act on it in ways that are thought-through and related to previous experiences, that has enabled mankind to rise to a position of mastery over all other species. The brain is essentially curious; it constantly seeks to make connections between the new and the known.

Despite the obvious fact that every one of the five billion people currently living on the earth has a brain, we still know relatively little about its structure and its operation. Quite simply we just take the brain for granted - that "little grey mass" of roughly 2.5 lbs has been just a puzzle. Now, however, new technologies, and new imperatives, are making it possible to learn more about its structure, organisation and - critical for education - just how it actually "learns". In a recent issue of Newsweek (20 April 1992) a key article on brain research claims - "the brain is the last and greatest biological frontier" - yet already we know enough to appreciate that "it is the most complex thing we have yet discovered in our universe". That is quite a statement. To educationalists it has to be a matter of profound concern. Maybe so many of our best endeavours "to fix" our teaching, and "to sort out and jack up" our school system, have failed because we have been too concerned with the external factors of teaching that we have given precious little consideration to checking our assumptions about how the individual brain works.

Brain research shows that each of us builds mental "models" of how we think things work. These models, our first approximation of relationships, remain deeply embedded in our consciousness and it is to them that we seek to relate new ideas. However powerful are these new ideas the shadows of the old model remain remarkably influential.

What is your "Model of Learning"? How do you think the brain works? What are your outline structures and frameworks? How did you develop these? To what extent was it a persuasive teacher, your own experience, or the "folk" traditions of our own culture? Are you constantly upgrading your model as a result of real experience....... or does the previous one continuously show through?
BRAIN RESEARCH

Research in neurology, and associated work in psychology, has proceeded extremely rapidly in the past decade; many new "facts" have emerged that have challenged existing theories about the operation of the brain, which are now leading to the formulation of new theories of learning. While many of these remain speculative and controversial, they are based on an ever increasing research base. They deserve serious consideration, particularly within an organisation such as Education 2000 so obviously committed to finding better and more appropriate ways for people to take responsibility for their own learning.

What follows is an attempt to draw from this research, material of particular significance to Education 2000 and its associated projects.

Research is showing the breathtaking complexity of the brain, both biological and functional. The structural complexity of individual brain is amazing; something in excess of a hundred billion neurones (or nerve cells), every one of which can make a connection (a synapse) with any other. Statistically this means that the possible number of interconnections in a single brain is greater than the number of atoms in the Universe!

Contrary to popular perception that it is natural to stop learning at some comfortably selected age, the brain does not have to be a wasting asset. Indeed, Nature ensures that when the brain is subject to rich sensory environments there is then an increase both in neurones, and the speed of synaptic connections. This literally results in the physical growth of the brain - it can get bigger, and heavier. Most growth in active neural tracts (brain plasticity) occurs in childhood, but it this can restarted at any stage in life and - perhaps most remarkable - even late in life and in brains that had previously received very little earlier stimulation.

There are, of course, negative physical factors; dietary deficiencies limit neural development; certain drugs severely restrict synaptic activity; certain chemicals added to food are thought now to either over-stimulate or repress, the brain's "indexing" capabilities.

As Winston Churchill was once heard to remark in the House of Commons "We shape our houses, and then they shape us."
Some of the earliest research suggested ways in which the brain was organised to deal with specific functions. This research, based largely on the study of brain damaged accident victims, helped to show the physical location within the brain of certain functions, but it failed to detect the fine interdependence of these sections on each other. Current research is showing that the brain operates to biological rules as a single system, rather than as a series of mechanistic structures responding predictably to given inputs as was suggested not so long ago.

The Issue

The "Crisis" in education is dominated by the failure of the system to ensure that all but a tiny minority of students reach acceptable norms of knowledge, and develop a range of appropriate intellectual skills. But, in reality, the issue is far wider, and more complex. Many of the critics of formal schooling are actually describing their deep dissatisfaction with the subsequent performance of those employees who, as students, were deemed to have succeeded by the standards of the school.

Conventional schooling can equip young people, most effectively, "to handle tasks for which no context has been explicitly introduced; to assume that new problems are instances of a class of problems that can be solved by a general rule; to memorise apparently arbitrary sorts of materials and to impose an organisational structure upon them; to reason in specific ways; to engage in dialogue about remote topics, and to succeed on tests and test-like procedures". Subsequent employment in institutions that value the same processes as the schools can be eminently satisfying for those who thrived in school..... "schooling" to them was highly relevant. Careers in the Civil Service, law, universities, schools can enable them to thrive.

Where the subsequent context of this work is different many school "successes" find this knowledge, and their skills, basically "flawed". They knew what to do - parrot fashion almost - when it was a question of performing routine tasks, but when forced to use their skills and understandings in unfamiliar surroundings very many people find to their cost that this "learning" was pretty shallow; it failed to give them a deep understanding. Deep understanding, the ability to so comprehend an issue that you can comfortably draw on this in a variety of circumstances, and explain it at a variety of levels, can be seen as ready measure of an individual's intellect. By this measure many apparently "qualified" people fail.
The crisis in learning is far deeper than newspaper headlines suggest. It will not be solved by defining standards in abstract reasoning. It involves a whole new appreciation of the need to create opportunities for the individual brain to grow, and to be "exercised", in ways which really challenge the individual not just to memorise but to constantly search for ever-expanded meaning in every learning task they undertake.

Natural Learning

The phenomenon of the apparent "natural" learning of languages in young children has fascinated parents and scientists for generations. It is now widely accepted that a child is born - in language development terms - not with a blank slate, but with a whole series of predispositions that, given even a rudimentary environment with which to interact, ensures the "natural" growth of language.

At birth, it is postulated, particular sections of the brain concerned with the use of language are already "lined up" to be ready to respond to external stimuli, and to do so in a very particular order. Regardless of the "mother tongue" the processes seem to be the same in children world-wide, with language development as the consequence of natural social and cultural interactions.

Language is by no means the only set of "predispositions" that are thought to exist in the newly born child. There is now powerful evidence to show that a whole range of bodily functions are mastered by the brain actually before birth; indeed it now looks possible that the mental patterns which condition the control of walking have been fully activated within the unborn child - and actually practised in the security of the womb - but then "stored" at birth and recalled only as the physical strength of the baby grows, and the environment is amenable.

Symbol Systems

Research is now showing that language - which in research terms is a "symbol system", is only one of many symbol systems that children seem predisposed to develop..... gesture, graphics, play, quantity, ritual, cultural customs....... the list seems endless. Just as in the development of language, so the young child seems to come to manipulate ideas in a pre-formed "natural" order. In these symbol systems too there seems to be a natural pre-disposition to learn in a pre-formed and economic way.
"We are a species that has evolved to think in language" states Howard Gardner, "to compute with logical and mathematical tools, to solve problems using our physical and mental skills, to understand others, and to understand ourselves." Recently Gardner has shown how each one of these is susceptible to capture in a symbolic or a notational system.

Symbol Systems and Forms of Knowing (intelligences) are the initial, and most basic, building blocks out of which a young child starts to construct meaning. Evidence is mounting to show that the brain functions at its best when its search for meaning is not constrained just to a single symbol system, or intelligence, but is sought in all its relevant forms. Not only is the brain multi-faceted, it actually works best when it is operating at a number of levels simultaneously; far from trying to simplify issues, the brain actually thrives on complexity, ambiguity, and constructive uncertainty.

To recap:

"....... reluctance to learn cannot be attributed to the brain. Learning is the brain's primary function, its constant concern, and we become restless and frustrated if there is no learning to do. We are all capable of huge and unsuspected learning accomplishments without effort" -

Frank Smith. "Insult to Intelligence" 1986

Environment

While it is becoming increasingly recognised that the new born child "far from being a blank slate, or a vortex of confusion....... emerges as a remarkably well programmed organism" (Gardner 1991) this only heightens the interest in the impact of the environment on the child's learning. At this stage only a single point will be raised; the traditional form of nurture over countless generations up to the last four or five, involved the young child's development as part of the normal activity of society....... the child essentially "learnt on the job", benefiting enormously from a richly structured family environment, but gaining precious little in many others. It has only been very recently (in evolutionary terms) that society has sought to extend the environmental support by attempting to structure learning within an institutional context. That there remains a serious mismatch between the
child's "preferred learning styles" and the institutionalised structure of learning is at the heart of the current "Crisis in Schools", all the more obvious at a time when children feel less constrained to conform than probably at any previous time in evolutionary history.

It is through its interrelationships with the environment that the young child starts "to uncover" its mental pre-dispositions and makes society's experiences its own "part of the emerging mind of the child already exists beyond the skin of the child in the actions of the others around him" (Gardner, 1991).

**Mental Models**

Symbol systems, linked with the young child's sensory perceptions and growing appreciation of natural phenomena, leads, so research shows, to the young child setting up for itself theoretical frameworks into which it can "place" ideas, and explain relationships. While the idea of, say, a theory of life, or of matter, or of self and relationships may seem at first a sophisticated adult activity there is now increasing evidence that the voracious appetite "to make sense" of phenomena impels children to set up, quite unconsciously, what are best called Naive Intuitive Understandings by the age of 3, 4 or 5. The formation of such theories marks a critical developmental stage. Like a student taking notes in a new subject the brain is unsure of itself, even panicky, until it knows which subsection it is to use to store a particular idea, so these Mental Models act as frameworks into which the brain can fit new phenomena. Inevitably though, as with the student's notebook, if the subsections are wrong (or if the theory is basically flawed) then the accumulation of deep insight is prevented. Evidence is accumulating, moreover, which shows that so robust are these early Mental Models that many students, having at a later stage accumulated sophisticated knowledge in subjects such as physics or mathematics, never internalise this in ways which actually supplant their earlier intuitive frameworks. Gardner argues that, in every adult, there is abundant evidence of this "unschooled mind" struggling to re-emerge.

**Common Sense**

Perhaps it is in the proper understanding of these naive, intuitive understandings, that we see the origin of the often quoted "common sense", to which countless folk will have recourse when adult complexity seems too difficult to handle. Perhaps too, we see in these stages Natures robust, yet economic, ability to ensure through
evolution intellectual paths that would have enabled man for most of his history to cope adequately with most situations, without having recourse to "formal" instruction.

The Brain as a Multiple Processor

The brain operates simultaneously at numerous different levels, and tasks. In picture language it can best be understood as a city seen at night time from a fast approaching aircraft. First its broadest outline appears - its shape; shortly its streets, parks and airfields give it its skeleton; then parts of the city seem to be moving - cars, lorries, trains, planes. Great expanses of light show factories working overtime; darker patches show other factories waiting for the morning, or areas of domestic housing with people asleep. A further analysis would show the interdependence of all that with hidden systems of drains, power supplies, educational facilities and communications ... and perhaps to complete and analogy areas of total darkness - or cemeteries - representing past activity. It is a series of systems set upon systems, some parts being directly and continuously interrelated while others lead a largely interdependent existence secure in the overall pattern.

The Active Brain

Research shows that the brain acts at its most efficient when it is processing information in a natural way, that is when all its senses are stimulated and it is absorbing new ideas and reflecting on, and processing these, both as wholes and in parts. When the brain is engrossed in challenging activity it tolerates uncertainty and ambiguity; it seeks to solve problems through establishing new patterns, or through the metaphor or simile. It tests its own mental models.

Essentially the brain is multi-faceted - it is holographic, global, interconnected. It both directs its perceptions as it searches for opportunities, whilst always on the alert for significant peripheral activity.

Memory

The operation of memory needs to be understood. Anyone who has ever played Kim's Game where first a tray of random objects in placed in front of you for 10 seconds to see how many can then be remembered, will know just how difficult this is in comparison to the same objects being presented for the same length of time but
set out in a systematic, related form .... all the long thin objects, separated from the
round soft ones, the ones related to a sport and others to a hobby or whatever. We
find it much easier to remember things that "make sense", and have to work very
hard at disconnected data.

Powerful evidence suggests that the brain has two distinct memory systems.

Work by Nadel and O'Keeffe, developed by Caine, focuses on Taxon and Locale
Systems. Taxon memory, it is suggested, essentially consists of a number of Taxon
systems specialising in different kinds of material: numbers, phases, words,
directions, etc.. Their common characteristics are that they have to be consciously
memorised. They are "content free" i.e. telephone numbers, rather than the
names of a house; codes, formulae and data; once established they are resistant to
change; and they are much influenced by extrinsic rewards. They have to be
memorised because they do not have a direct relationship with other information.
And, of course, they can be measured and tested; Taxon memories are the
lifeblood of examination systems!

The Locale system, with potentially unlimited space in comparison to Taxon
systems, is essentially a spatial Memory system. The Locale system is about
relationships in all their forms; about patterning; about things which "interest" the
brain....... Essentially the Locale system is that core of the brain which is
constantly seeking to "make sense" by relating the new to the known. It is
particularly active in relating ideas and information across the intelligences. It is
not as easy to classify or measure as a Taxon system, but its role in creativity is
essential. It is what helps us to recall, with near perfect clarity, instances of
amazing complexity which are, to the individual, memories of specific significance.

"It is in the recognition and use of the power of our Locale memory" says Caine
"that we begin to give credibility to the complex forms of instruction that are
needed to upgrade education"

It is within the Locale system that a learner is able to merge new ideas with already
formed concepts and patterns; it is here that the search for learning is generated,
consummated, and where new ideas are formed. "Ignoring the child's natural
memory is to ignore what the child can bring to learning. Without a better use of
our Locale memory system most teaching becomes meaningless and segmented"
Taxon/Locale Memory illustrated

Caine gives the following graphic illustration.

Visiting a distant city and being invited to dinner somewhere in the suburbs on the other side, provides a useful illustration of how the two processes can operate. To find the dinner location you can take instructions, and if followed exactly - first left, second right, third exit at the third roundabout - you are sure to get there; a single mistake and you are totally lost. Or, if you are a map reader, you buy a map. Maybe to get to dinner takes a bit longer but that time is rapidly recovered if you need to attend different dinners on subsequent nights. The map reader soon so "understands" the terrain that he builds such a mental model that rapidly he is finding his way unaided in the new city.

Rote learning, so beloved of formal education, works almost exclusively through Taxon systems. It is easier to administer, or to teach, than work dependent on the much more personal frameworks of the individual's Locale (map) system. Maps are an internal symbol system of great power, but personalised rather than standardised. Locale memory depends on intrinsic motivation ("I'm interested - I'll go for that"), whereas Taxon systems respond directly to extrinsic motivation ("I'll work for that...... I want the prize; the subject doesn't really interest me but that's beside the point"). To Education 2000 the biggest consideration has to be that rote learning is the stuff of teacher control ("I know how good I am by the test results of my pupils"); it is relatively easy to deliver, but it is not the home of deep understanding, creativity, problems solving, or critically, of learning - that is within Nadel and O'Keeffe's theory, a function of the Locale system.

"The crisis in education, part of which is the students inability to think and reason may be more easily understood when we recognise the abandonment by educators of rich map learning for goal-directed rote or symbol specific learning".

Emotions

"Emotion and Cognition are intrinsically interconnected" state the research papers; in other words the brain is as much influenced by emotions, as are the sweaty hands and the quivering lips, when facing a moment of high tension. Observation and endless measurement of emotions are leading to formulations about how feelings are developed, and possibly modified ..... and why it is that, under pressure, even
apparently sophisticated and emotionally balanced people revert to primitive
behaviour and simplistic "solutions". Evidence is strong that the brain contains
"layers" of emotional responses.

Work conducted by Paul McLean over the past 30 years sees the brain having three
if not four interdependent layers. Within the brain, McLean postulates, there is
residual "archaeological" evidence of earlier forms of emotional processes which
operated at distant periods in man's history. The most "basic" layer (that which is
located in the brain stem) he graphically calls the Reptilian Complex. "Gut
reactive" rather than thinking; tough rather than calculating, the Reptilian
Complex processes actions related to actual physical survival and the maintenance of
the body; its actions are automatic, ritualistic and highly resistant to change. It is
the animal part of the human.

Surrounding this is the Limbic System which appears closely related to theLocale
memory system and helps to give context to actions. The Limbic System
represents the first steps away from sheer animal instincts towards forms of altruism
and deferred gratification. ("I'll store these nuts for the winter rather than have a
feast now!").

By far and away the largest of the layers is the Neocortex which handles the
development of symbol systems, language, the processing of data, reflection and
speculation. It makes logical and formal thinking possible, as well as planning for
the future. It deals with complexity and tiers of meaning.

The Neocortex can be seen as the home of concepts, the Limbic of emotions, and
the Reptilian Complex of behaviour.

McLean, and others, see these layers as being recreated within each generation
almost as if Nature is afraid to lose what served it well in earlier times. Indeed
with the discovery of the Pre-Frontal Cortex, shown to be located within the
forehead, McLean sees a growing specialised fourth function of the brain. This is
related neither to the intelligences nor to the other 3 layers of emotion. He argues
this to be the location of the "adaptive behaviours" - the abilities to plan, analyse,
sequence, learn from mistakes, make decisions, increased compassion for others,
and the ability to "put ourselves in somebody else's shoes". It is just these higher
order skills which increasingly commentators on education in the latter part of the
20th century are saying will be so essential to society's survival. The Pre-Frontal Cortex is, as it were, the brain of the future.

A New Survival Response

McLean as a neurologist sees in these activities of higher level learning the emergence of a new survival response. In somewhat more graphic language Peter Senge, of MIT wrote in "The Fifth Discipline": "Real learning gets to the heart of what it means to be human. Through learning we re-create ourselves. Through learning we become able to do something we never were able to do. Through learning we perceive the world and our relationship to it. Through learning we extend our capacity to create, to be part of the generative process of life. There is within each of us a deep hunger for this type of learning. It is as fundamental to human beings as the sex drive".

In a fascinating expansion of this argument Senge, whose basic thesis is that only through high level learning can an organisation hope to survive, says that it essential to be continuously expanding one's capability to create. "Survival learning is not enough....... Adaptive learning must be joined by generative learning, learning that embraces our capability to create".

Recent research shows, as with all aspects of brain research, that these parts are all interconnected - they shape and influence each other. To "teach" to one (or to stimulate one by itself) is to throw the system; "concepts", "emotions" and "behaviours" (all beloved of educationalists) cannot be treated in isolation. Quite simply our emotions influence our memories; powerful emotions be they grief or ecstasy, create most powerful memory tracts. Emotion simply energises memory .... remember how a youngster can naturally rattle off the football scores, or quote the nonsense rhymes of Bart Simpson at length.

The Brain and the Body

Research is only now beginning to show the relationship of bodily state to the function of the brain.

"At one time a compartmentalised view of the human body was generally accepted. Recent knowledge of the anatomical and functional links between brain and body point in a different direction. Brain researchers now believe that
what happens in the body can affect the brain, and what happens in the brain can affect the body. Hope, purpose, and determination are not merely mental states. They have electrochemical connections that play a large part in the workings of the immune system and indeed, in the entire economy of the total human organism”.

Norman Cousins "Head First - The Biology of Hope" 1989

**Challenge**

The brain operates at optimal levels when it is reacting to highly challenging situations which it deems to be within its competence to handle, and when the fear of the results of failure are minimal. At this stage "stress", which is known to lead to the excretion of high levels of cortisol in the body, is generally a positive state leading to the emotional "highs" associated with successful and purposeful self-motivation. Such an emotional state is associated with the ability to "index", or cross reference, between layers of emotional, conceptual and behavioural responses; the brain is able to perform without inappropriate tension; the learner is sufficiently confident to be able to afford to relax, and also to take risks and explore creativity. This purposeful (and halcyon) state is characterised - as those who remember once getting there will readily testify - by a strong sense of ownership of the solution, sense of control of the learning, positive collaboration, happiness, togetherness, and a willingness to delay gratification. "All systems go" is an appropriate epigram.

To generate learning environments in which rewards are willingly delayed, indeed to create generations of thinkers sufficiently sophisticated to be able to take short-term decisions that support long-term goals, must be now more than ever the concern of all those involved with structuring learning strategies appropriate to the increasing complexity of modern society.

**Threat**

Stress, when seen as a challenge, can be a most positive experience, but when it causes the individual to so lose confidence in himself that he feels helpless and powerless, then stress becomes threatening. Both levels of stress are associated with high levels of cortisol within the blood, when the individual becomes overwhelmed by the problems, the stress becomes chronic with the excretion of additional hormones that lead to very specific physiological states such as
depression, immune disorders and heart disease. What form of stress will dominate depends, in the first instance, on the state of mind of the individual. . . . . body and mind influence each other.

Emotion, too, effects cognition. High levels of cortisol, unmediated by the chemicals which are associated with the positive aspects of stress (adrenaline) have an immediate impact by chemically inhibiting the indexing capacity of the brain and progressively limiting the use of Locale memory in favour of repetitive-type content-free Taxon systems. This narrowing of perception under threat has come to be called "Downshifting", as the individual forsakes the challenge of complex tasks (such as critical thinking and problem solving) in favour of familiar routines of belief and behaviour. . . . . even though intellectually these no longer "make sense", or are believed in. The ability to cross-reference, to follow themes or to be flexible is also replaced by "safe routines".

Downshifting is the physiological response to distress, or threat. It effects the emotions as well as the intellect. The more threatened and helpless individuals feel the more their emotions react, and the less able they are to accept delayed gratification, or to deal with ambiguity or uncertainty. It is also thought that Downshifting makes an individual more suggestible to extrinsic motivation as their ability to depend on their own higher order thought processes are reduced, and internal motivation evaporates.

**Downshifting and Creativity**

Creativity - "all systems go" - seems to result from the confident acceptance of challenge and the pursuit of goals accepted as being of great importance to the learner. It is facilitated by "autonomy, greater interest, less pressure and tension, more positive emotional tone, higher self esteem, more trust, greater persistence of behavioural change, and better physical and psychological health" (Deci and Regan, 1987). Intrinsic motivation stimulates reflective and creative learning.

Some research is now suggesting that external reward and punishment reduce intrinsic motivation and the associated creative and problem-solving skills.

Why does this happen? Several factors seem to be involved, "Rewards for specific outcomes encourage people to focus narrowly on a task, to do it as quickly as possible, ignore other information, and take few risks". External rewards are
much influenced by peer group pressure. "People respond as if being controlled by the reward. They feel less autonomy and experience conditions associated with chronic stress........ not all rewards have the same effect. The issue seems to be how rewards are used. There are ways to buffer the effects of reward so that they do not preclude creative work" (Caine, 1991).

"The more complex the activity, the more it is hurt by extrinsic reward" (Kohn, 1989).

Lozanow (1978) suggests that individuals build frameworks within which to handle stress - he calls them "Social Suggestive Norms". They constitute beliefs which individuals develop about their own capabilities, and what is appropriate, correct and generally true. When threatened we raise our barriers, and effectively Downshift. One is our perception of what is logically consistent, and we are threatened when asked to accept something which conflicts with this. Secondly there is an intuitive/affective barrier which is activated when we believe an action is inappropriate. Thirdly there is a moral/ethical barrier that is activated when our moral values are challenged. These social suggested norms are deep-seated, probably related to the Mental Models of early childhood.

Schools and Downshifting

"In practice, many of the demands that we impose on students, ranging from placing unreasonable time limits on learning and restrains on individual thinking, to excessive competition and motivation by means of shame and guilt, will cause all but the most resilient of students to Downshift. In fact, by this definition, we suggest that most schools maintain most students in a Downshifted state and prevent them from engaging in the complex learning that we profess to desire and need". (Caine, 1991)

In looking for solutions it would seem essential to help each individual to understand these barriers/models and give them the appropriate degree of safety and opportunity to creatively explore and go beyond their immediate limitations.

Motivation

The stimulation of Motivation is a matter of much interest; just why is that some people seem to have an abundance of intrinsic motivation? Work which started with the research of Resnick in the 1980s in Pittsburgh, and which is being further
developed at the Institute for Research on Learning (IRL) at Palo Alto in California, believes that a socially oriented view of learning is the key to motivation.

"When you consider motivation as separate from learning, it becomes difficult to motivate people, and you have to rely on external gimmicks. But what motivates people is their innate desire to belong. People are automatically motivated to learn whatever they need to learn in order to become a member of the community to which they want to become", states Penny Eckert, a Socio-linguist at IRL.

The Institute, which is an extension of the work originally set up by Xerox on Artificial Intelligence, challenges three deeply ingrained notions that are at the heart of conventional education. (i) That knowledge resides in the individual brain (ii) that knowledge can be transferred, intact, from one person to another, and (iii) that it is abstract, formalised knowledge that is valuable. The Institute sees the emergence of a contrasting theoretical framework. (i) Learning is a social rather than an individual activity (ii) Knowledge is socially constructed (iii) Learning is a function of one's membership of "Communities of Practice". The implications of this are stark; formal knowledge - the kind taught in text books and measured in standardised tests - is knocked off its pedestal. New respect is accorded to "situated" understanding, the kind that results from our interactions with the world, and each other.

Interpreting this in terms of literacy, Eckert goes on to say "We don't see literacy as a separate skill, but as a constantly evolving, changing practice. Literacy involves not only the ability to read and write, but understanding the social relationships between you and whoever else is involved in using a document. So, a person may develop excellent alphabetic skills but be quite unable to use them to good effect in a range of situations".

Communities of Practice

Interpreting further the views of IRL, Etienne Wenger (1991) contrasts the essential social nature of our being with the strangely individualistic nature of formal education - the individual acquisition of knowledge, the mechanical instruction of classrooms and lecture halls, didactic teaching, text book, and hours of lonely, solitary study.
The mentalistic view is prevalent - learning is concerned with abstract material, and is the specific concern of the individual. These "myths" have costly implications; within the UK alone we spend some £20 billion on formal, institutional education each year. We still see schools as specialised, sequestered institutions, different from "real life". Our programmes do not give youngsters experience in engaging in actual practice. Technologies are designed to support the individual rather than the group. Progress and intelligence are assessed in ways which do not capture their true essence.

Information only takes on meaning in the context of "communities of practice" which give it its essential value. IRL analyses ways in which human knowledge is created, sustained and transformed in communities of practice. "Communities of Practice are everywhere, but their boundaries don't coincide with those of the formal organisations in which they exist. The school divides students into formal classroom grouping; but it is the students own informal social cliques that comprise their communities of practice........ We overlook the pervasiveness of the informal in our lives. Communities of Practice are the places where things get done, because they organise themselves around what matters to their members".

Wenger suggests certain guidelines if people and communities are to be empowered.

* Pay much attention to the informal, improvised, inventive, negotiated character of the community.

* Be aware that it is in the social community that real learning takes places, and values are created.

* View individuals as members of communities in multiple and complex ways - support them, don't dominate them.

* Every "formal" institution is an ensemble of interconnected communities.

* Boundaries and peripheries are where there is high potential for change - support these.

Wenger concludes "Those who can understand learning as a social phenomenon and can translate their understanding into learning organisations will be the architects of tomorrow". Little wonder that Education 2000 sees so much of importance in these ideas, and is so concerned when it sees legislation further reinforcing the concept of learning as being individual, abstract and unchanging.
"Learning is not something that requires time out from productive activity; learning is the heart of productive activity".

Shoshana Zuboff "In the Age of the Smart Machine", 1988

**Learning In School and Out**

In a Paper delivered in 1987, Resnick looked authoritatively at the contrasting learning styles at the school and the workplace. This Paper showed that the school is a special place and time for people, discontinuous in some important ways with daily life. Resnick identified four general classes of discontinuity between the cognitive activity of the school and "working life".

Firstly, schooling focuses on the individual’s performance, whereas out of school mental work is often socially shared. Secondly, schooling aims to foster unaided thought, whereas mental work outside school usually involves cognitive tools. Thirdly, school cultivates symbolic thinking, whereas mental activity outside the school engages directly with objects and situations. Finally, schooling aims to teach general skills and knowledge, whereas situations-specific competencies dominated actual work.

Resnick noted that major corporations, with their big emphasis on "classroom" type training programmes were perpetuating the problem started in schools - employees, like pupils, were just "not involved" in their courses. Ways needed to be found, said Resnick "to reintroduce key elements of traditional apprenticeships in forms appropriate to modern conditions of work", while "we need to identify and closely examine the aspects of education that are most likely to produce the ability to adapt....... rather than train people for particular jobs, schools should focus on preparing people to be good adaptive learners", and to do that it would have to change its working practices significantly.

"Cognitive Apprenticeship; Making Thinking Visible"

In an article with this title, Collins, Brown & Holum (1991), unpack the significance of apprenticeship as a model of learning, and seek to show some generalised cognitive strategies that could be used within more "formal" education.
By working alongside a craftsman, and in a small team of other apprentices, 
apprenticeship was "the vehicle for transmitting the knowledge required for expert 
practice" in a variety of crafts. Apprenticeship was a naturally well structured 
activity (but the over-structuring of which was largely responsible for its demise in 
Britain in the 20th Century), in which the apprentice was helped to see and 
understand particular aspects of the craft. Apprenticeship literally "made thinking 
visible" in a way in which the processes within school are assumed, rather than 
explicit.

In traditional apprenticeship "the expert shows the apprentice how to do a task, 
watches as the apprentice practices portions of the task, and then turns over more 
and more responsibility until the apprentice is proficient enough to accept the task 
independently". The eventual production of the masterpiece - the demonstration 
piece in which all aspects of craftsmanship are demonstrated - marks the transition 
from apprenticeship to master-craftsman; in its techniques it is similar to what 
happens now in high tech companies where young and old learn together.

It should be noted, too, that the master was no hypothetical expert, but was the 
working practitioner who, in exchange for training the apprentices, delegated to 
them progressively those aspects of the task he was working on which were within 
their competence, so allowing himself more time to refine the skills which only he 
could implement. Think of Michael Angelo with his apprentices working on the 
ceiling of the Cistine Chapel - a true "team" activity; or of a politician working on 
an important speech with his ghost writers; or a university professor feeding off the 
research of his students in the setting out of some new thesis.

Studying these processes Lave (1988) stresses the interplay between observation, 
scaffolding (limited support processes), and the increasing independence of the 
apprentice. Observation helps the apprentice build a conceptual model of the 
target task, and design strategies for its execution; it provides an "advanced 
organiser" into which a task can effectively be sub-divided; it provides a 
theoretical framework for feedback, and an internalised guide while working on his 
own.
Of equal significance was the social context in which the learning took place - every activity was embedded not only in the culture of the trade, but in the artefact being constructed, to which end the apprentice was but one member of the team. Each apprentice was concerned for the skill and expertise of his colleague. "Team Spirit" is not a sporting concept dating from the English Public Schools; it was the hallmark of the apprentices.

There are two important differences between traditional apprenticeships and the kind of "Cognitive Apprenticeship" that could be established for more institutionally based learning. Firstly, the learner has to come to appreciate just what the learning/thinking processes are which he is now developing; the teacher has to help the student to identify what new skills are needed, and which existing skills need strengthening - this was the "stuff" of apprenticeship....... a battery of skills and techniques that the craftsman knew well, and subsequently used as appropriate. Secondly, in traditional apprenticeship the sequence of learning is conditioned by the nature of the actual, real-life task. The apprentice's motivation to learn the sub-components of the task is set by their interest in the finished product.

Interpreting this into formalised learning strategies for today the young employee, still fresh from school, faced with a complex and novel issue should know whether it is the particular technique of evaluating evidence as learned in history, or assessing personality as discovered through a study of literature, or through objective testing of data as prescribed in science, which will be the more appropriate technique in finding a solution.

"In a literate society, it has become essential to create learning situations in which these earlier forms of knowing come to be utilised in conjunction with the formal ways of knowing that grow out of, and are tied to, specific disciplines....... A judicious introduction and integration of apprenticeship methods within a scholastic setting should yield students whose potential for understanding is engaged and enhanced".

Howard Gardner
BRAIN-BASED LEARNING

From what was already known from hard won experience, and from what is now becoming better understood about how the brain works, and how humans naturally use learning to create things of value for themselves, what helpful generalisations can now be made to our understanding of learning? The list which follows, and the short explanation of each, build on the preceding descriptions. The implication of these ideas for people working within Education 2000, and others who share its aims, are spelt out in the last section.

1. **The Search for Meaning is innate**: in trying always to "make sense" of our environment man has emerged as the pre-eminent learning species. Learning is a most natural activity - as fundamental and instinctive as the sex drive. The brain automatically registers the familiar, whilst always searching for the novel. Learning and self-esteem are intricately inter-connected; the ability to learn gives confidence in facing the uncertain and the changing. To frustrate the individual's capacity to learn is to destroy much of what it means to be human.

2. **Learning is a 'Social' activity**: Learning, within conventional education, has emphasised the individual, and the individual's accumulation of abstract knowledge. Increasingly it is becoming clear that learning is a social activity much motivated by the wish "to belong" to "communities of practice". Equally while the conventional view of learning has been what the individual "knew" for himself, the emerging framework is more to do with how the individual can access and use that knowledge which resides within the community. "Learning is an important way in which people function together as communities" (Institute for Research on Learning). The difference is profound....... is a person of "value" because of all the information they hold in their "brain-box" or because of what they can contribute from their own interpretations to a Knowledge Community?

3. **The brain is a parallel processor**: it is doing many things at one time - thoughts, emotions, imagination and predispositions all operate simultaneously. The brain operates most effectively when it is dealing with "natural" situations - that is when it is dealing with multiple complex and concrete experiences in which it is interested, and which it thinks it can draw a benefit. It processes parts and wholes simultaneously....... it works with both generalisations and specifics at the same time. In other words it is both trying to sub-divide and compartmentalise ideas, whilst always looking at the possible relationships and discontinuities.
Equally the brain is adept at both focusing its attention while also being sensitive to peripheral perception; nothing, as it were, escapes its attention. This is its natural state. To create "uncluttered" learning environments where the brain has no room for peripheral perception is to frustrate its natural activities. Many "serious" students work better with music in the background; many pupils feel more secure at a corner of the kitchen table than they do in the silent isolation of their own rooms.

This goes further than just distinction between focused and peripheral perception to include unconscious processes as well as the conscious. Our consciousness can only cope with a certain amount "what we are discovering....... is that beneath the surface of awareness an enormous amount of unconscious processing is going on" (Campbell 1989) or, as Caine says, "thus we become our experience, and remember what we experience, not just what we are told".

Every aspect of experience affects the brain, and its inclinations towards learning. The implications of this are profound; meaningful learning cannot take place in surroundings which the learner "feels" are incomplete.

4. Learning and Emotion cannot be separated. What we learn is influenced and organised by emotions and mind sets much conditioned by expediency, personal biases and prejudices, to bolster our self esteem and our sense of the values of our community. Simply we learn when we are motivated; we learn best when we are personally satisfied. Emotions cannot be switched on and off; their sequencing is more complex and problematic than the operation of the curriculum....... yet they are a vital contribution to academic success, with powerful influences on memory, and indexing capabilities.

5. Physiological factors directly influence the brain. Stress and threat affect the brain differently from peace, challenge, boredom, happiness and contentment. In addition to physiological stages of development (which differ most markedly between individuals), so too natural rhythms of the body have powerful short term implications for the alertness of the brain. Evidence is accumulating to show that the actual neural tracts and synapses (brain wiring) can be permanently harmed by a protracted discontinuity between what the brain is able to do and what it is being required to do.
Relaxation, and the need for lengthy periods of active reflection, relates both to emotional and physiological influences on the brain.

6. **There are at least two different memory systems.**

There is a marked difference between our natural, spatial memory system that does not need "rehearsals" and allows for "instant" memory of experience (the Locale), and that other form of memory that deals with facts, data and skills in isolation, and which we know requires rigorous rehearsal and practice if this is not to be lost (the Taxon). Up to the age of 6 or 7 there seems to be a regular, natural interchange between the two systems but from that stage onwards an over-emphasis on external rewards to support Taxon memory is thought to set up physiological barriers that inhibit transfer between Taxon and Locale, i.e. if the brain thinks it is being "got at" it protects its Locale from being "defiled". Both systems are critical to man's survival. Without Taxon skills man would be unable to perform basic routine tasks other than with much wasted effort; without a Locale system man could not begin to "make sense" of his environment.

The brain is always trying "to make connections" between existing patterns, schemata, and new patterns. In this it acts both rationally, in sensing logical patterns, but also creatively in as far that it looks for unusual links. The individual's brain appears to have limitless storage for pictures, or map-like, patterns which offer teachers a massive resource into which to plant new ideas which, if the learner once accepts as his own, become part of their natural accepted "stock in trade", rather than held in short term memory which needs constant repetition and practice.

Memory is enhanced when it has to search for the relationships of new patterns to existing ones, rather than when new patterns are simply presented to be learnt.

The implications of this are immense. Educationalists have to find ways of drawing out the significance of both spatial and rote memory. To recap..... "The challenge is to deliberately embed new Taxon content in rich, life-like, well orchestrated experiences that require genuine interactions. In effect, we need to give students real experiences, engaging all their systems and their innate curiosity and involving them in an appropriate physical movement, social interactions, practical projects, uses of language and creative enterprises" (Caine).
7. The brain learns best within highly challenging, low threat environments. The brain works at its optimal level when it is in a state of relaxed alertness (experiences positive stress - "eustress") and is fully involved. The brain welcomes challenge; it prefers to search and to discover patterns for itself; it handles complex situations more easily than it does artificially contrived ones. Its capacity to solve problems is directly related to the richness of its environment; the more stimulation, the more active is the brain. Research on "Learning in School and Out" stresses the importance of the brain at being able to use appropriate "tools" to extend its capability; learners need ready access to books, videos, computers, telephones, facsimiles...... not because the brain is specifically tuned to any of these but because, once the learner knows of their capability, he knows that to act without these is to perform sub-optimally.

Should the challenge become overwhelming, however, or the resources become inadequate to the task, the brain downshifts, becomes less flexible and reverts to automatic and earlier, more primitive, forms of behaviour.

8. Every brain is unique. It would seem easier for society to accept that every individual is physically different than it is to accept the equally complex differences within individual brains. Although every individual has the same set of systems, are all inheritors of a mass of "pre-dispositions", these are integrated differently in every brain. As research shows further evidence for "stages", and "pre-dispositions", so too it shows that there is extraordinary diversity in the detailed sequencing of that development, and in its chronology. Because the practice of learning actually changes the brain, the more we learn the more unique each brain becomes. The earlier that learning starts, and the richer that environment, the greater and the deeper that diversity.

The more reflective and inquisitive the learner, the greater are the chances that new understanding will subsume older, more naive, understanding; without such reflection and internalisation (the Locale system) there is no "sorting out" of the new with the known and ideas tend to be held more as rote memory without impacting the learner's "mental models".
A final quotation from Howard Gardner:

"We run the risk of investing incalculable resources in institutions that do not operate very well and that may never approach the effectiveness that their supporters - and for that matter their detractors - would desire..... It is my own belief that until now we have not fully appreciated just how difficult it is for schools to succeed..... we have not been cognisant of the ways in which the basic inclinations of human learning turn out to be ill-matched to the agenda of the modern secular school."
SOME IMPLICATIONS FOR EDUCATION 2000

1. Whole System Change; there is powerful confirmation in these ideas that Education 2000's identification of a new Model of Learning within which (a) formal pedagogic and other changes within school, have to be linked, (b) to the opportunities for informal, non-institutional learning in the community, (c) supported by a greatly enhanced use of Information and Communication Technologies and other "learning resources".

2. Strategic Aim - A Reminder. Education 2000 can't change the system head-on..... It is about building examples of such change which is so persuasive that the "system" adopts the idea as its own.

3. From Teaching to Learning. We know that this is difficult to achieve within the classroom; in truth the change which it implies is far more than pedagogic. It is about a commitment to accept change. The implications go far beyond schools. Does society want things which are safe and predictable, or is it yet ready for new ideas and change?

4. Community Support. These changes (3 above) can't happen unless the community accepts its role to provide a rich learning environment.

5. Balance in Use of Resources. These changes will inevitably change the conventional use of resources (teachers, adults other than teachers, books, computers, etc.; classrooms, and community learning resources). The Projects have to demonstrate this...... and stimulate change in the use of normal funds, not just Project funds.

6. To Start Young is Critical. Confidence in the individual's ability to handle learning for himself/herself must start young - the Trust's early emphasis on secondary education was wrong.

7. Learning Styles - have to fit much more closely the "natural" learning framework of the brain.
8. **Learning is a Social Activity.** A prime motivation to learn is the desire to belong to groups which value certain knowledge; learning energises communities. New community structures will emerge; their shape could be influenced as much by the needs of learning as earlier communities were shaped by the needs of the manufacturing industry.

9. **Learning and emotional development have each to be supported.** To function effectively young people need support in both areas; in a period of massive change and uncertainty it is critical that the desire to learn is intrinsic and personal, rather than simply a response to the need "to raise standards to get a job".

10. **Assessment.** A good working model of assessment of Learning Communities, which draws out the desired learning objectives, is now essential.

11. **Further Research is essential**...... or at least the ability to search and draw conclusions from, the increasing mass of research and development projects world-wide; the Trust must "study widely, but implement in fine detail".

12. **Politics.** The Trust is, and has to be, apolitical. It is in the business of positively influencing power bases by the force of the argument. It has to avoid confrontation. It has to project the value of issues; it has to prevent the easy identification that always seeks to polarise issues. Our agenda is long; almost always longer than the normal political decision-making process.

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Doncaster 9 July 1992