John Eggleston Memorial Lecture 2010

Models of Change: The future of design education

Ken Baynes, Visiting Professor, Loughborough University Design School
Brochocka Baynes, Co-founder, Design Dimension Educational Trust

Abstract
This paper discusses design and design education in the context of four major social and environmental concerns identified by Bruce Archer in 1973: overpopulation; pollution; depletion of natural resources; control. It argues for the social and economic importance of design education in primary and secondary schools. It identifies 'designerly thinking' as an aspect of cognitive modelling directed towards imagining viable alternative futures.The paper then reviews the potential of design educational activity, focusing on seven themes:

- The aims of design education.
- The significance of practical education.
- Encouraging the imagination.
- The creative value of aesthetic awareness.
- The value of learning through making.
- The creative relationships between designing and making.
- The educational purpose of doing design projects.

Research agenda are identified in key areas: the nature of imaginative activity and its significance in education; graphicacy and cognitive modelling in design.

Key words
design education, designerly thinking, cognitive modelling, research agenda

RESEARCH

Introduction

The John Eggleston Memorial lectures provide the opportunity to look at some of the most fundamental issues in Design and Technology education. In the past they have effectively set the agenda for future development but also identified emerging problems. On this occasion the aim is to re-visit what I regard as key issues in the effective delivery of design education for all children and young people. I want to stress the great potential of Design and Technology while also suggesting areas where its energies might usefully be redirected and where change is clearly needed. I would like to contribute to a greater sense of purpose in the subject.

You may have noticed two things are missing from tonight's set-up. The digital projector is not in action and the big screen is not animated. There will be no PowerPoint illustrations to my lecture. It will be words only …or not quite. I hope – and believe – there will be imagery in the room. The pictures will be in your heads. I invite you to see the images I might have shown not on a screen but in your mind's eye.

I hope the lack of illustrations will serve to illustrate my theme more effectively than could ever be done by illustrations on a screen.

My focus is on an extraordinary capacity of the human mind and its significance for our lives and particularly for general education.

What can you model in your mind? The brain constantly creates and re-creates the present moment in a life-long picture show. It can also recreate the past. Memory is a part of our identity and a storehouse of experience. Both these abilities – consciousness and memory – are essential aspects of being human and shape our personal and cultural lives. But we can do something even more remarkable: we can imagine future possibilities. It is this that has allowed us to dominate the planet and enabled us to create a human world within – and dependent on – the natural world.

According to the *Oxford English Dictionary*, imagination means:
'forming a mental concept of what is not actually present to the senses'.

In *A Midsummer Night's Dream*, Shakespeare gives to Theseus a wonderful definition:

> 'The poet's eye, in fine frenzy rolling,
> Doth glance from heaven to earth, from earth to heaven;
> And as imagination bodies forth,
> The forms of things unknown, the poet's pen
> Turns them to shapes and gives to airy nothing
> A local habitation and a name'

If the word had been in use at the time, Shakespeare could just as well have referred to the 'designer's eye' and said that the designer's imagination turns 'the forms of things unknown…to shapes and gives to airy nothing a local habitation and a name'.

As PowerPoint illustrations here, I might have flashed up the iconic image of a bald Shakespeare, the wooden 'O' of the Globe Theatre, Titania's fairies and possibly the late great Frankie Howerd as Bottom. Can you visualise them?

How many of these you can recreate in your mind's eye will of course depend on your personal experiences and how far they have become part of the shared British culture.

The *Oxford English Dictionary* adds a further definition of imagination:

> '[a mental concept that] does not correspond to the reality of things'.

This won't do for the designer's imagination for above all it is concerned with the 'reality of things'. We could say perhaps of the designer's imagination: 'a mental concept that does not correspond to the reality of things as they are at the moment, but might be made to be so in the future'.

At the highest level, designerly talent is as unusual as musical or literary genius. But as with music and language, design ability is also a universal attribute of human beings. People have always used their designerly skills in creating a domestic environment and often in their everyday work. In the past such skills were usually developed 'on the job', cooking was learnt in the kitchen, work skill in an apprenticeship, formal or informal.

Studies of children's mental abilities, and particularly their rich imaginative lives, show that they develop designerly abilities at a very early stage. Neuroscience suggests that the basic ability to design and understand design is hard-wired in humans but that it expresses itself in a great diversity of ways depending on experience, education and culture.

The ability to imagine and model alternative futures has been made potent by the exponential growth of science and technology. Design ability pushes technology forward but also domesticates it. Design, since the industrial revolution, has played a key role in bringing technology to market. In a free market economy, design has found a dynamic and volatile partner. Together they have transformed everyday life, created wealth and helped to turn society upside-down.

The human ability to imagine alternative futures has been made all the more important because science and technology now provide society with tools to bring irreversible change. The speed with which the forms of things unknown become known and tangible was accelerated to a point where cultural, social and moral frameworks find it hard to keep up.

Nearly forty years ago, Bruce Archer told a government sponsored conference about education that it was his 'sincere conviction' that a 'massive broadening and deepening of design education in secondary schools…is overwhelmingly the most urgent need for the survival as well as the happiness of mankind'. It was an extraordinarily bold claim – one that John Eggleston would almost certainly have endorsed. My aim is to put forward that claim once again. But I would make an addition. In my view the pre-requisite for a 'massive broadening and deepening of design education in secondary schools' is to do the same for primary schools.

In case the concerns of 1973 seem remote and irrelevant, Bruce made his claim for design education against a background of economic difficulties, environmental crises and social uncertainty. He spoke of 'the four great crises facing mankind'. The first three are immediately recognisable:

- the crisis of overpopulation;
- the crisis of pollution;
- the crisis of depletion of natural resources.

None of these has gone away. To them Bruce added a fourth:

- the crisis of control.

This does not resonate so immediately but it turns out to be very topical indeed. Bruce was highlighting the disillusion and alienation that many people experience in contemporary society. He spoke of unintended consequences and catastrophic accidents resulting from rapid technological innovation; of institutions, such as banks, out of control; of environmental and social decay.

Bruce lamented the loss of 'traditional values'. I have never been a great enthusiast for these, nor do I subscribe to a romantic vision of the past. In many aspects of life, the present is measurably more liberal and successful than most of the past. However, what still rings true today is people's anxiety about the future and their lack of confidence in our collective ability to act for the collective good. We are anxious because we seem not to have a coherent vision of a desirable future and, worse still, doubt our ability to bring it about.

In 1973, governments had begun to take design seriously but it was on the economic significance of design that they focused. Educationalists followed their lead. Of course Bruce recognised the economic significance of design but it is clear that he also had something of wide significance in mind. I believe he chose his words with care: he was talking about a wider set of environmental, social and psychological values. I am impressed by the fact that he refers not only to the survival of mankind but

to its happiness. What did he mean? Surely he was thinking of design ability and design awareness as antidotes to the alienation and sense of powerlessness inherent in the 'crisis of control'. In 'designerly thinking' he saw one of the few cognitive media capable of coming to grips with an uncertain future.

My own recent work strongly bears out this view and I want to suggest some of the things that this could mean for education in general and for Design and Technology in particular.

Over the past ten years, I have tried to understand what happens in the mind when somebody is designing. This work has reached a climax this year in a series of seminars which began at the Design and Technology Association's Conference in 2009. My aim has been to share findings and invite contributions. I have tried to look at designing from four different perspectives:

- evolutionary biology;
- neuroscience;
- cultural history;
- child development.

Evolutionary biology and neuroscience have provided the most general framework. The way we use our 'big brain' comes from our evolutionary history which, in turn, has 'hard-wired' capacities and potentials which express themselves in distinctive ways in different cultures. Children follow a pattern of growth which is partly hard-wired but which is also influenced by the culture into which they are born.

'Designerly thinking' turns out to be a key element in the story of humanity. Evolutionary biologists characterise us as occupying a 'cognitive niche' in evolution. We are able to construct 'causal models' of the world and to use these models flexibly and creatively in our mind's eye in our responses to the environment. Seen in this context 'designerly thinking' is a further niche within the wider cognitive niche. It is precisely this kind of thinking that has enabled us to construct the made environment within the natural environment.

Designerly thinking expresses itself in a variety of ways. As I list a few of them, please use your own ability at mental modelling to see them in your own mind's eye:

- I can sketch the future, perhaps on a napkin at a dinner.
- I can talk about it, perhaps with like-minded colleagues, but also in a formal presentation trying to persuade a client.
- I can make rough models of my idea, making it visible to myself.
- I can make an exquisitely detailed model of it, so realistic that we can imagine using it or walking through it.
- I can express its proposed structure in mathematical models.
- I can represent its proposed performance in charts and diagrams.
- I can 'run it' in a computer simulation.
- I can write a detailed specification supported by comprehensive working drawings so that you can go ahead and manufacture it.
- I can create an illustrated story about the kind of person that might want to use and buy my proposed product.
- I can make a story board for a film showing how sound, vision, set and story can be brought together.
- I can model the hoped-for economic performance of a design proposal.
- I can build a prototype and try it out.
- I can invite users to do their thing with prototypes or mock-ups.
- I can even engage in large-scale experiments with real people and real places or products.

I argue that in the light of the problems facing humanity, our current approach to the curriculum is fatally flawed. As a nation, we continue to emphasise the acquisition of knowledge rather than the exercise of the imagination. We continue to emphasise the acquisition of knowledge rather than the creative application of knowledge. We continue to emphasise knowledge of the past at the expense of learning how to shape – and control – the future.

The traditions of Design and Technology mean that it is well placed to take a lead in developing the kind of curriculum we need.

How can we make the best use of subject traditions, skilled teachers and existing good practice? I believe we need to revisit some knotty conceptual issues and attempt to sharpen our understanding of our aims. In particular, I want to focus on seven topics:

- The aims of design education.
- The significance of practical education.
- Encouraging the imagination.
- The creative value of aesthetic awareness.
- The value of learning through making.
- The creative relationships between designing and making.
- The educational purpose of doing design projects.

Aims of design education

Design education has always found itself squeezed by subject rivalries and by two apparently conflicting goals. Should priority be given to nurturing future design

professionals or to providing the mass of people with access to designerly skills and knowledge about design? The response to this dilemma has generally been to go for a watered down version of professional design education. This top-down approach has led to some excellent practice and particularly at the upper end of secondary schools allows gifted students the opportunity to do outstanding work.

I have been equally excited by some of the pioneering work in Primary schools. Triggered by the National Curriculum, it showed that children could engage in designerly thinking at their own level of skill, knowledge and experience. Teachers worked on a 'bottom up' approach that built on insights into children's minds and particularly their emerging imaginative capacity. So far this kind of practice is the exception rather than the rule but it provides an encouraging glimpse of the potential in young children.

A future curriculum could emerge from these two areas of excellent practice. Part of the development work needed would be to create a bridge between the two.

Aims need to be relatively simple and something like the following might be an effective framework:

- To provide pupils and teachers with a challenging, absorbing, entertaining and satisfying opportunity to work and study together.
- To give every child the opportunity to learn about design and designing at their own level.
- To give pupils with particular aptitude in design the opportunity to develop their ability as the basis for a possible career in an area related to art, design, engineering, craft or technology.
- To provide every child with design skills and knowledge relevant to adult life, particularly home-making, the environment, self expression and social engagement.

At the same time I would want to shift the centre of gravity in the curriculum towards the environment. I would highlight not only our responsibility towards the natural environment but equally the extraordinary significance of the made environment. We shape it and it shapes us.

The approach to design education for everyone could begin by rethinking the idea of 'consumer education'. Consumers are now see as passive choosers, shuffling the pack of goodies on offer in stores, garages and estate agents. See them instead as proactive. It would be good to re-christen them 'domestic designers', shaping their own lives and their own environment. Beyond personal and family health and well-being should come a positive attitude to the future with a growing sense of the effectiveness of thinking globally and acting locally. The ability to visualise, discuss and work towards the future depends on learning modelling skills and developing the imagination.

The significance of practical education

As we have seen, biologists characterise *homo sapiens* as occupying the 'cognitive niche' in evolution. This might suggest that, in human intelligence, theory comes first and is superior to practice. In fact, this is not the case. The essence of human intelligence is not only to link theory and practice but also to learn from experience. Gaining experience is crucially a matter of acting in and on the world. Human beings have developed the art of advancing theory by means of practice and experiment.

Humans 'try things out'. They do this not only in the arts, science and design and technology but also in every other sphere of life from social organisation and politics to sexual behaviour and personal relationships. In many fields of human endeavour 'trying it out' – practice – is the key to the advancement of knowledge and a driving force for 'progress'.

Evolutionary theory, neuroscience and studies of child development all go to show that it is a fundamental error to separate theory from practice in education. In most human activities, theory develops partly from practice and practice changes in response to theory. In many areas of learning, practice cannot in fact be learnt from a study of theory. It is, for example, impossible to learn how to drive a car until you actually sit in a driving seat. Books on how to drive – or the teacher's verbal instructions – only make sense when they can be tried out in the real situation. On the other hand, if we want to learn about the history of motoring or the physical and engineering principles behind the internal combustion engine, it is necessary to turn to the store knowledge on the subject.

In the case of design, I would argue that the only way to learn how to design is by actually designing. On the other hand, if you want to learn about the history of design, books, museums, documents, TV programmes and designed things (amongst other sources) will be essential providers of information. Knowing about the history of design may also make you a more creative and fluent designer.

This difference used to be called the difference between knowing HOW and knowing THAT. The two are clearly interdependent but it turns out that there is a further dimension to the psychology of learning beyond either

proficiency in a skill or the accumulation of knowledge. It is knowing WHY. The most powerful educational experience is to have the excitement and satisfaction of applying both skill and knowledge to achieve a worthwhile goal. It is in the PURPOSEFUL application of both skill and knowledge that the true relevance of education is made clear.

We now often talk of a knowledge-based society. Governments all over the world have realised that somehow the economic wealth of society is related to the amount of knowledge in it. But this subtly misses the point. The crux for a successful economy is not knowledge itself (though knowledge must be there) but the ability to deploy knowledge creatively in responding to and shaping change. Unlike the majority of the school curriculum, which emphasises what is already known, there also needs to be an emphasis on making the future. Three key questions worth asking pupils are: 'How did it come to be like that?'; 'What value has it now?'; and 'How should it be in the future?'. The first emphasises the known, the second calls for critical analysis and judgement while the third encourages speculation and imagination and the application of knowledge and practical skills to human needs.

Encouraging the imagination

Designing calls for the use of many different skills and many different types of knowledge. Only two are, in my view, indispensible. They are: imagination and aesthetic fluency. We will look at aesthetic fluency later. Imagination is essential because design is only called for if the future is unknown. If we already know what we need to know, there is no necessity for 'designerly thinking'. We already have the causal model ready in our minds or in the store house of past experience and past products.

Imagination is also essential in order to understand and evaluate design proposals. It is a common experience to find that potential users of a product or environment cannot extrapolate from drawings, models or computer programmes to imagine what the finished result will be like in reality. Yet this is a skill that is essential both in organising life at home and exercising democratic rights over large scale planning decisions.

Children's cognitive development has been much studied. Their imaginative development has been comparatively neglected. The importance of play is accepted as an essential part of growing up and it is recognised that playing requires the ability to imagine and pretend. However, imagining and pretending are not given the dignity they deserve though both are fundamental to human creativity. Equally, the changes to the world of imagination that happen at puberty have not been seen as an educational opportunity though the heady mix of idealism and despair produces radical flights of the imagination. Both childhood fantasy and teen-age rebellion are of potential interest to design education because they engage with the forms of things unknown.

If I was looking for a dynamic growth point in design education it would be in the interweaving of childhood and adolescent imagining with adult experience. The learning potential on both sides of this equation could be very great.

We need a lot more research on the imagination and how it can be fostered by teaching and learning. Here is an area where Design and Technology should take a lead and in conjunction with other subjects join with psychologists and cognitive scientists to tackle an important research agenda.

- What happens in the mind when the imagination is in action?
- How do mental and physical models and modelling media support the imagination?
- What is the connection between imaginings which are pure fantasy and those directed to shaping future reality?
- What are the developmental stages in the emergence and growth of imagination and how do these relate to other areas of intelligence?
- What teaching and learning methods are effective in fostering the imagination, in general and specifically in relation to designing and understanding design?
- Is it possible to evaluate pupils' imaginative development?

The cognitive value of aesthetic awareness

Aesthetics are wrongly identified with surface appearance, the icing on the design cake. Alternatively, they are wrongly identified with expression, an emotional gesture or personal hallmark. In fact, aesthetics are fundamental to all human thought and action, and particularly in designing and making.

All human cognition depends on input from the senses. The big brain's causal models are built from sensory input. Action in and on the world is carried out though the senses and it is feedback from the senses that leads us to modify our actions and to learn from experience. Seeing in the mind's eye relies on models constructed from sensory experience and these models are externalised and understood through sensory output and input.

Humans live in an environment, natural or made, of shapes, forms, colours, movements, actions and reactions.

It is these sensory, aesthetic qualities which are the basic 'stuff' of designerly thinking just as words are the basic 'stuff' of linguistic thinking.

People have strong reactions to their surroundings. A place can be disturbing or reassuring, for example. These perceived qualities come partly from 'wired in' reactions that are the result of evolution and partly from cultural values that vary from place to place and from time to time. Our aesthetic 'intelligence' partly determines the thoughts we have and the actions we take.

I am thoroughly frustrated with the idea that 'it's just a matter of taste'. Uninformed taste is not taste. The truth is that humans have created a formidable body of knowledge about aesthetics and the way people respond to the made world. Take, for example, the mathematical basis of pattern, proportion and form. Historical cultures, East and West, have explored and documented the underlying harmonies that are evident to humans. Designers have used their insights sometimes without knowing the theory. The key reason for studying design history is to be able to read the aesthetic handbook represented by the products of the past.

Aesthetics are central not only to designed things but to the way we communicate them through models. Fluency in the use of aesthetic media contributes directly both to the clarity with which a designer can externalise design ideas and the efficiency with which they can be shared by other people.

At Loughborough we have been exploring the idea of 'graphicacy' as an important element in the curriculum. Research suggests that this is a further area for cross-curriculum development. The cognitive value of drawing and computer graphics, for example, links the arts with the sciences. The ability to read and interpret graphic images is essential in everyday life as well as many trades and professions. Design and Technology could take the lead in this area by joining with others to revisit and re-define the role of aesthetic awareness and graphicacy in the school curriculum.

The value of learning through making

Primary teachers have a distinguished record of understanding the pedagogical value of 'learning through doing'. It provides a vivid and absorbing way into many areas of knowledge. In recent years 'learning through doing' has become less common throughout all sectors of education. Worse still, one particularly valuable expression of 'learning through doing' has suffered acutely. This is 'learning through making'. Cost, time and social attitudes have all contributed but the end result is an unbalanced curriculum offering, the loss of a brilliant strategy for learning and the impoverishment of children's school experience.

By learning through making, I mean something rather more than the production of images and objects that has traditionally been a central element in art and craft education. In my view, it is essential for children to have such experiences, but here I am casting the net a little more widely.

The issue was clarified for me many years ago when looking at work by seven and eight year olds at Severn Beach Primary School near Bristol. Rather than simply write poems or stories (again, essential activities in their own right) the children had made simple 'miniature books'. These were enchanting objects in themselves and a source of great pride and satisfaction to their creators. More importantly they had involved the children in a wider world of skills and decision making:

- The books had to be planned.
- The relationship between words and pictures had to be thought out.
- There was a purposeful process to creating the text: rough drafts; editing; final draft; word processing; proof reading.
- There was a similar purposeful process to making the illustrations.
- The whole had to be brought together in a series of page layouts within the limitations of producing an 8, 12 or 16 page book from folded sheets.
- The resulting book was shared with others and the class had a lively discussion about the difficulties and pleasures of authorship, editing, illustrating, graphic design and book production.
- The class had enhanced their skills, their self-esteem and their confidence.

You could say that this was a design and make project and certainly the children had designed and made their books. However, the work put graphic design activity into the context of the wider world of books and the broad range of activities necessary to bring a book into existence.

Over the last decade, I have been involved with the Focus on Food Campaign. Our aim has been to establish cooking as an essential experience for all children and young people. Cooking is of course a life-skill, the centrepiece of home making. However, we also saw cooking as the most vivid way into the wider world of food education.

Here is how we justified our approach:

> 'Most making projects provide children with experiences that are totally relevant to the dilemmas and potential of the modern world…Making may involve working with other people, it will usually involve planning ahead, confronting difficult problems of communication and resources, and reaching an outcome which is real and therefore can be tested. There is a realistic interplay between the theory, practice, personal expression and social awareness'.

We attempted to demonstrate that cooking – making a meal or a dish – was not simply a narrow educational experience. We showed that making in the kitchen looked outwards towards the environment and society and inwards to the science of food and why ingredients behave as they do. Above all, we attempted to provide personal relevance, helping children to take control of their food lives and so enjoy the experience of eating while achieving better health.

My point is that we need to make the best possible educational use of the fact that we are involved with making. Making has revolutionary educational potential. It is up to us to present the case for making and demonstrate its value.

The creative relationship between designing and making

The National Curriculum presented the relationship between designing and making in a particularly unhelpful way: one before the other. It is true, of course, that there is a sequence of events in designing and making that moves towards an end result. However, the rigid stages imagined in the National Curriculum might have been carefully designed to stifle creativity.

I will summarise some of the negative effects:

- The assumption that the making simply carried out the design. In reality, making will throw up problems and possibilities that can change the original design for the better and make it more practical and realistic.
- The assumption that most designing will be drawings or digital media. In reality, making in the form of 3D-models, test-pieces, lash-ups, colour tests and other 'roughs' is a way of designing.
- The assumption that what is made must be a fully realised product. In reality, this limits the areas of design which pupils can experience. This requirement has led to environmental design being largely excluded even though it is of fundamental importance.
- The assumption that what is made must be the result of a lengthy design process. In reality, this is not universally appropriate. Food is a good example. The requirement has led to trivial design work that has detracted from a number of important areas of craft skill.
- The assumption that all designerly work should begin from an identified need, problem or brief. This has tended to stereotype the nature of design activity. From an educational perspective it is enriching to have projects of varying length and with a variety of starting points. In reality, design can start from a particular material, a technological innovation or an aesthetic insight. It can start from playing around and trying things out.

In summary, designing and making need to be reunited. Sometimes making can be free, expressive and experimental. At others it needs to be directed towards a prescribed goal. In either case, designerly thinking can permeate the process. Designing becomes a state of mind, an innovative attitude to the whole of designing and making rather than a stage in the process.

The educational purpose of doing design projects

It is important to be clear about the role of design projects in design education. Why should children and young people engage in designing and making as the main teaching and learning medium? The question is particularly sharp because most pupils will not become adult designers or makers. What the majority need is an understanding of designing and making as they affect their everyday lives and the big environmental and technological issues facing society.

Here are some of the arguments for the pedagogical value of designerly project work.

- Designerly thinking skills can only be developed by using them.
- Making skills can only be developed through making.
- Working on a realistic design project puts learning about theory into a relevant context.
- Projects can be designed to allow for progression, development and differentiation.
- Projects encourage a constructive interaction between the pupil and teacher in pursuit of a shared goal.
- Projects can be designed to allow for individual and group work.
- Carefully chosen projects can allow the pupils to experience designing and making in a number of different fields or to pursue personal preferences and interests.
- Carefully chosen projects can range from the highly speculative to the immediately useful and practical.
- Projects encourage an assessment philosophy which really does value the 'journey' that the pupil has made. The pupil's own evaluation finds a logical place in the work.

Design and make projects also have a number of pitfalls. Two are particularly significant and are inter-related.

- There is a temptation to overvalue and hence to over-assess the finished product. Clearly, outcome needs to be seen as a window through which to view the learning experience rather than an end in itself. This perception has to be shared by pupils, teachers and assessors.
- There is often a mis-match between the pupil's imaginative vision and the pupil's ability to achieve it in reality. Since making skills are likely to always be emergent, the scope for disillusion is to some extent built into the situation. Good teaching can deal with this.

My conviction is that Design and Technology has a central role to play in design education. It is well-placed to develop a future-orientated curriculum with designerly thinking at its core. If it does this, it will make a massive contribution to our ability to deal creatively with the economic, environmental and social problems facing us. As Bruce believed, it will contribute to 'the survival as the happiness' of humanity. At every level, this is an idea worth having.

References

Since a large part of the lecture is a reflection on many years of direct experience, it does not lend itself to conventional referencing. However, here are some avenues for further reading and research.

• *Cognitive modelling and design*
Much of the background can be found in the Loughborough University Orange Series Models of Change based on the series of seminars I gave during 2009/10. These are available online at:
https://dspace.lboro.ac.uk/dspacejspui/handle/2134/1686

• *Bruce Archer and design education in the 1970s*
See the D&T Association/DERG publication:
Bruce Archer, Ken Baynes and Phil Roberts, A Framework for Design and Design Education: a reader containing key papers from the 1970s and 80s (2005). This is available from the Design and Technology Association.

• *For more on neuroscience:*
Steven Pinker (1997) *How the Mind Works* Allen Lane, The Penguin Press, London

Semir Zecki (1999) *Inner Vision*, an exploration of art and the brain, Oxford University Press, Oxford

• *For more on graphicacy and drawing:*
See research by Loughborough Design School's Design Education Research Group (DERG):

Xenia Danos, Eddie Norman, Ian Storer and John Robson (2010) 'Identifying Continuity and Progression in the Development of Graphicacy'. In David Spendlove and Kay Stables (eds) *D&T – Ideas Worth Sharing: The Design and Technology Association Education and International Research Conference*, the D&T Association, Wellesbourne, UK, 33-52

Cheng Siew-Beh and Eddie Norman (2010) 'Visual Communication of Technology for Designing and its Links to creativity and Innovation'. In David Spendlove and Kay Stables (eds) *D&T – Ideas Worth Sharing: The Design and Technology Association Education and International Research Conference*, the D&T Association, Wellesbourne, UK, 13-28

...and publications and digital materials from the Campaign for Drawing by Eileen Adams, which are available at:
www.drawingpower.org.uk

kb2@waitrose.com

RESEARCH