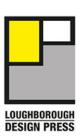# MODELLING AND DESIGNERLY THINKING: STEM TO STEAM

This paper was written for the Thinking through Drawing 2012: Drawing through STEAM international symposium, which was held at Wimbledon College of Art from 12-14 September 2012

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INTRODUCTION

The crucial role of modelling in designing, and hence in determining human futures, was recognised in the pioneering research completed at the Design Education Unit under the leadership of the late Professor Bruce Archer at the Royal College of Art in the 1970s and 80s. Further research has explored and developed this early work (eg Cross, Dorst and Roozenburg, 1992; Lawson, 2005; Cross, 2006; Kimbell and Stables, 2008), but it cannot yet be said that key differences distinguishing Design and designerly methods, from Science and the Humanities, and their methods and epistemologies, are fully recognised. This would be the case both within the academic community and outside it, and represents a significant failing of the design research community.

During 2009/2010 the Design Education Research Group (DERG) at Loughborough University organised a seminar series led by Ken Baynes[1], who was a Visiting Professor in Loughborough Design School (LDS). The seminars were intended to begin to address this omission and lead to an academic book entitled *Models of change: the impact of 'designerly thinking' on people's lives and the environment*. This book is soon to be published by Loughborough Design Press (LDP), which is a newly-formed publisher that has been established in order to develop a body of work focussed on Design and designerly methods, and particularly in the context of design education[2].

A parallel development is 'STEM to STEAM' which is being led by the Rhode Island School of Design (RISD) in America. This paper has been written with two objectives:

- To share some of the outcomes of the DERG seminar series;
- To consider some of the parallels with the STEM to STEAM agenda.

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[1] Seminar 1 was presented in June 2009 at the Design & Technology Association's *International Research Conference* and Seminar 2 at the *1st international Visual Methods Conference* at Leeds University in September 2009. Seminar 3 was presented in association with the visit of the *Quick on the Draw Exhibition* to Loughborough University in December 2009. Seminar 4 was held at Goldsmiths University in London in April 2010.

[2] Ken Baynes' book was published in 2013 and the title shortened to *DESIGN: Models of Change*.

'MODELS OF CHANGE' SEMINAR SERIES

The ideas underpinning the analysis of Models of Change were initially presented as 4 separate seminars.

- Modelling and Intelligence
- Modelling and Design
- Modelling and the Industrial Revolution
- Modelling and Society

Each had an associated freely downloadable Orange Series publication (available at https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/1686). They explored the nature of 'designerly thinking' and particularly the use designers make of modelling – mental, physical and digital models of products, places and communications that do not yet exist. The following quotation is from the introduction to the seminar series:

> *'Designerly thinking – is one of the most dangerous of all human characteristics! It is the use of mental and externalised models in conjunction with our adaptable 'general purpose' intelligence that has allowed us to achieve dominance over the whole of the natural word. Specialist design modelling, when associated with science, technology and the market economy has led to an extraordinary expansion of the made world. This has been driven by economic growth but has also created economic growth. Design has had the key role of bringing technology to market, creating and helping to sell a stream of innovative products and services. Taken almost for granted in the 'developed' world, they are totally inaccessible to very large segments of the world's population. It remains far from certain that these taken for granted products and services could ever be extended to the whole of the world's population without causing catastrophic environmental collapse'.* (Baynes, 2009)

It is important to establish the place of Design and designerly thinking in the organisation of society. It matters because human futures are fundamentally determined through designing, which reflects the human capacity to bring together the past with present realities in imagining future possibilities. It is the human capability to model such possibilities in the mind, as well as externally, that largely determines the outcomes. From the DERG's immediate perspective it is the future of design education that is the key concern, but these ideas and concepts also impact on wider research agendas. In 2010 Ken Baynes followed up this seminar series by giving the John Eggleston Memorial Lecture at the 2010 Design and Technology Association Education and International Research Conference[3]. The abstract is shown below.

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[3] This lecture has now been developed into a book with contributions from a number of colleagues *DESIGN EDUATION: A Vision for the Future* that was published by Loughborough Design Press in 2013.

'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 modeling 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.' (Ibid:11)

There is not space in this paper to revisit all of these, but the following quotation addresses one of the key matters in relation to the current concerns.

'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.'* *(ibid: 11)*

The significance of this matter is that over four decades ago, people were concerned about the kind of issues that face the world today, and equally concerned about advances in science and technology as responses to them. Consider this quotation from the Editorial for *Green Slate* by Paul Allen.

> *Taking perspective from key milestones is a very important part of any transition process, and the 20th anniversary of the Rio Earth Summit is a useful way-marker. Thousands have re-assemble in Rio to take stock of what has, and has not, been achieved over the past two decades. But 2012 also offers us another useful milestone: the 40th anniversary of the birth of 'alternative technology'.*

> *The concept of 'alternative technology' signalled a huge shift in our socio-technical evolution. Before the shift, science and technology were gods, unequivocally associated with progress and improvements in standards of living. Scientists were heroes. However as technology began to confront the limits of the ecosystem, questions had to be asked about the limits to material growth, damage to natural systems and depletion of resources.*

> *This enquiry gave rise to a pivotal conference at the Architecture Association in 1972, where CAT [Centre for Alternative Technology]'s Peter Harper coined the phrase 'alternative technology' (AT). More than just harvesting energy from alternative sources, it meant opening up of technology to both comprehension and control by citizens and communities, challenging market dominance and focusing on benefits to living things, not just the economy.'* *(ibid:3)*

Different people will have their own views about where and when the environmental concerns about the planet began, and many would no doubt cite the Club of Rome Report published in 1972: *The Limits to Growth* (Meadows et al). However, it is a reasonable assertion that it was around this time. The lack of progress concerning environmental agendas in the last 40 years is lamentable, but, if anything, there seems to have been even less progress concerning education policy in relation to these matters. How can it be that when economic and environmental challenges – or crises – impact on our global society, that governments world-wide turn to STEM? (Science, Technology, Engineering and Mathematics). It seems remarkable that there are still any believers in a 'technological fix': astonishing that they are apparently in the majority.

Education policy should reflect designerly methods as much as those of the Sciences and the Humanites. Numeracy, literacy and articulacy are recognised as key skills, but not graphicacy (or visual literacy), and this in a world that is becoming increasingly dependent on visual communication. Why is this so? In 2011, the DERG began to turn its attention to these matters and organized an IDATER Online conference concerning Graphicacy and Modelling.   The proceedings can be freely downloaded from https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/9015.   Table 1 (Baynes, 2011), shows some of the key aspects of 'modelling and design' and related aspects concerning graphicacy education.   It seems self-evident that general education should be addressing 'modelling and design' in order to equip people to create preferred human futures. It seems equally self-evident that graphicacy should be a key aspect of general education in developing the necessary competences to exert design capability.   It is equally self-evident that they are not.

TABLE 1 KEY ASPECTS OF 'MODELLING AND DESIGN' AND GRAPHICAY EDUCATION (BAYNES, 2011:25)

	MODELLING AND DESIGN The capacity and its application to the 'human-made' environment	GRAPHICACY AND DESIGN Vision and its significance for the 'human-made' environment

1	• *Homo sapiens'* BIG BRAIN is capable of constructing, understanding and using CAUSAL models of the world. This allows humans (amongst other things) to:
	  o React creatively to unexpected situations
	  o Predict – and so control – the behaviour of the physical world, plants, animals and other humans
	  o Plan ahead and work with others to realise these plans
		• *Homo sapiens'* STEREOSCOPIC and COLOUR VISION is capable of depth perception which allows humans to experience a three-dimensional space filled with brilliantly coloured, movable objects. This allows humans (amongst other things) to:
		  o React creatively to objects and places and to appreciate their visual/spatial ability
		  o Distinguish 'what' from 'where' and so predict and control the behaviour of the physical world, plants, animals and other humans
		  o Manipulate the visual realm to make stored meanings

2	• *Homo sapiens'* unique cognitive ability to deploy causal models is used in every aspect of life. However,	• *Homo sapiens'* unique cognitive ability to deploy visual images is used in every aspect of life. However, IMAGING (in the mind and externally)

		MODELLING (in the mind and externally) is ESSENTIAL to DESIGN ACTIVITY. Since designing is about things which do not exist yet, the only way to articulate them is through models - models which 'stand for' and 'make visible' what could be.	is ESSENTIAL to DESIGN ACTIVITY. Since designing is concerned with visual/spatial futures which do not exist yet, the only way to model them is through GRAPHIC MODELS – models that 'stand for' and 'make visible' what could be.
3	•	Designers imagine every aspect of future products, places or images. This is sometimes referred to as IMAGING or 'seeing in the mind's eye'. However, designers need also to be able to use 'the mind's ear' and every other sensory descriptor so that they can imagine (for example) appearance, function, economic viability, marketability, and wider social or psychological impacts. This mental handling of future possibilities is what might be called 'designerly thinking'	• Designers imagine every aspect of future products, places or images. However 'seeing in the mind's eye' is particularly potent. In a graphic model, proposals are vividly present. The visual is essential to 'designerly thinking'.
4	•	Designers make professional use of designerly thinking. However, the ability to imagine alternative futures is shared by all humans. This enables people at large to shape their personal and family environments and to understand or 'read' and react to the designed world.	• Designers make professional use of graphic modelling. However, the ability to 'read' and make images is shared by all humans. Graphic models help to 'make visible' alternative futures. This enables people at large to shape their personal and family environments and to understand and react to the designed world.
5	•	Modelling in the mind (designerly thinking) is extended and shared through the medium of	• Much modelling in the mind (designerly thinking) is extended and shared through graphic models. The fluent use and understanding of

	externalized models. These take many forms. Words, numbers and images can be used as well as more specialist media such as plans, maps, technical drawings, simulations, prototypes, storyboards and computer programs. These, and the contents of the designed environment, are the active ingredients of design culture.	visual media and an understanding of the visual/spatial content of the designed environment are amongst the active ingredients of design culture.

STEM TO STEAM

It goes 'without writing' that there is a chasm between the positions presented in the DERG models of change seminar series and STEM as strategies for working towards sustainable futures. However, what might the relationship be to STEAM? Here is a further quotation from Baynes (2010).

> *'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.'* *(Baynes, 2010:12)*

The STEM to STEAM initiative is in its early phases, but there are a number of quotations in the report of 'Gathering STEAM in Rhode Island' (2012), which give some indication of the positions that it embraces .

> *'RISD's STEAM initiative also aims to spur an innovation revolution, create jobs, and help Rhode Island and the nation maintain a leading edge in the global marketplace'. (Neil Steiberg)*

> *'At RISD we believe that creativity is a right. The studio practice model creates innovators – people who can see differently and solve problems differently … Through tools such as data visualization and modeling, artists and designers are already working to make science understandable and real, and helping people to understand complex issues. By*

injecting art into the innovation dialogue STEAM will help the country stay competitive in the 21st century'. (John Maeda)

'We all make choices based on art and design everyday. We all look at the world through the prism of the arts. Our challenge is to bring that awareness to the general public'. (Nancy Carriuolo)

(Andrea Castañeda) … spoke about art as a trifecta of qualities (innovation + creativity + art and novel design) that can infuse curricula in biology, mathematics and more to help students come up with novel and creative solutions to challenging problems'

(Charlie Cannon) *presented some of the STEAM research already taking place at RISD and its importance for producing new forms of knowledge. For example … RISD is working with Brown, the University of Rhode Island and nine other schools throughout the state to look at marine impacts of climate change and develop visual techniques and communication strategies for scientists to share their findings with a broader audience.*

(Stephen Lane) *spoke about his medical device company's grounding in fine art and design, and noted that although STEM technologies enable their work, design is the driver. Those who are using technology, science and math for creative ends are the people who are changing the dynamic.*

(John Maeda) noted the similarities between studio-based education and project-based learning, along with the contributions of art and design to every field – from stem cell research and health care to entrepreneurship and education. … Rhode Island is a leader in this area of integrating art and design into its economy… It's time for this message to be heard both locally and nationally. (ibid, 2012)

Clearly we're never going to agree on the spelling of 'modelling', ('modeling'). More significantly, there seem to be hints of art and design acting as a catalyst for a 'technological fix', in these quotations, which would put some distance between STEAM and the positions being advocated by the DERG, but there are also similarities in the positions. Notably 'designerly thinking' (to use the DERG term) as a spur to creativity and innovation, the need for new visualisation tools (in DERG terms, to enhance the designers' perceptual span, Jones (1970)), a universal capability in everyday use, a strategy for enhancing the school curriculum, the need to address climate change, the promotion of entrepreneurship and the need for advocacy. The crucial matters concern the ends, as well as the means.

The future of design education must be in enabling humans to harness their modelling capability to design a sustainable future. It cannot be about breathing life into the unsustainable systems and practices that have prevailed for the last four decades with all their unintended consequences alongside the benefits they have brought.

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