

## **02: The architecture of adaptive environments: synthesising the real and the digital**

**Alan Penn**  
**UCL Space Syntax**

I am going to talk about research being at the frontier of new technologies. The reason for looking at research in this context is partly because at that boundary - right at the end of what new technology is making possible - design, research and practice are forced to come together. The development of communication technologies over the last twenty years is something which is directly related to architecture.

Architecture has been around for thousands of years; it is a communication technology. When we place walls we do it in such a way that they inhibit communication, when we place doorways and thresholds and vistas we do it in such a way that they create communication. I think we have a claim to say that architecture is primary amongst the communication technologies. That is one reason why under new and evolving types of technology, architecture is probably moving faster now than it has since relatively early days.

Frank mentioned knowledge and he mentioned the importance of research for architecture precisely because of the nature of knowledge and the relationship of research in defining what knowledge is. He also mentioned that there is an uncomfortable relationship between research and design and I want to be a bit more explicit about this because it seems to me that there are two kinds of research, and there are two kinds of knowledge that are involved in producing them. There is knowledge of 'what if' consequences; what if I design it like this, what is the outcome going to be? This tends to be explicit. Quite often we get it wrong, we have bad theories and we apply those and we get bad architecture as a result. There is also tacit knowledge; know-how. If I look at what we teach our students in undergraduate and diploma courses, by and large the nature of architectural education and design is about a laying-on of hands, it is about the transmission of tacit know-how; how to approach this really difficult task of designing. Both of these it seems to me, in so far as they are actually about transmission of knowledge, are also fields for research, it is just that they require quite different approaches to research.

I am going to take you through a series of examples, starting off with where I come from in Space Syntax-type work. The first is the work we did on Trafalgar Square with Fosters and others. I would like to show that what we did there was a direct product of academic research impacting on the way that we live our lives and the way that we think about design. Trafalgar Square has a Grade 1 listed wall, part of our heritage, but we found that the square itself was remarkably unproductive in cultural and social terms. Can that be explained? Yes, it can. We tracked the movement of Londoners in the square and found that they move around the edges of the space, in spite of the fact that in Trafalgar Square there are two staircases in the northern corners that allow you to create a diagonal route. During the time that we observed it only a couple of people did those diagonals. We found that in this space tourists are rapidly separated from locals. That was the nature of it; it felt segregated. There was a hope that if one created a staircase down the centre that the space would become like the computer-generated view in illustration 1.



*Illustration 1: Computer-generated view of proposed central staircase*

It was impossible to convince those in power in this process that you should demolish a Grade 1 listed wall just on a whim or even on the say-so of a very eminent architect. We needed proof. We needed some understanding of how that structure of space led to the mixing of people or inhibited the mixing of people. We needed to be able to argue the case for a very difficult negotiation between the requirements of heritage and the requirements of tomorrow; what it should be like - the biopic of Frank's view.

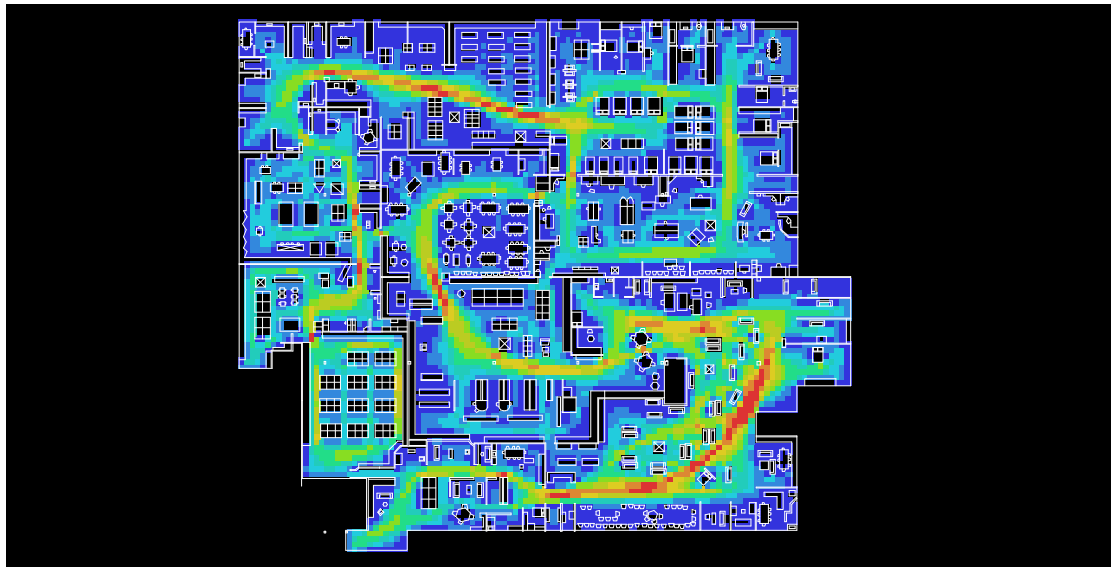
We made some predictions: if you build it like this, that is what it will be like. You can go back and you can say "Were our predictions correct?" This is a powerful link between the need for bringing evidence and understanding to bear (the explicit side of knowledge) and the design process. Alongside this is all the messiness of politics, pragmatics, of actually getting things done, and it plays its role in that.

There is some science underlying this. In order to generate the knowledge that allows us to make the predictions we have to go out and we have to observe and understand how it is that people move. I will be showing you some agent-based simulations where we generate computer agents which only have vision of their environment. That is all they have - they can only see ahead of them. They can give you a generalisable forecast of how real people move through an area of space. Agents, without particularly great intelligence, can be used as a way of beginning to predict general movement patterns in spatial structures. Why is that possible? It is possible because the way that people behave and the way they move are similar, by and large, from person to person.

My second example is the Ikea stores. As Susie Steiner, Editor of the Guardian's Space supplement says 'When you're inside an Ikea store, you must come to terms with a near permanent state of bewilderment: shelves stacked with flat brown boxes labelled with random codes and names; a yellow road which takes you inexplicably through bedrooms when all you wanted was some kitchen handles. And then, then,

when your emotional temperature is rising and you can feel a panicky hotness around your ears, you will be faced with Ikea's version of customer care - an underpaid teenager, trained in psychic disengagement who'll tell you they're out of stock.'

I have said that we can do analysis that predicts how people move around places. When we first started looking at Ikea's showroom we found something completely baffling because our analysis showed nothing of the sort. What it showed was what, in urban studies, we would describe as a well-formed urban core; a centre with spokes pointing out in various directions of accessible space and so forth, nothing like the sense that you actually get when you walk around these places. If we observe how people walk around the spaces, as one of my Masters students did, you follow people from the door and you see that they take the sinuous route around the yellow road.



*Illustration 2: Simulated shopper movement patterns using agents with forward facing vision.*

We set our little agents walking. They have forward-facing vision, they move by selecting a point ahead of them at random from anywhere they can see; they are just random little automatons. They move towards it and as they do they feel the view change, they move next to a wall or past a pillar and a new vista opens up. Every three paces they select a new destination at random. They end up following the yellow brick road because although the pattern of space looks proto-urban, in fact when you put forward-facing people into it they miss all the shortcuts because they have been very carefully placed; all the shortcuts that exist in Ikea are always behind you, so if you want to get there quickly, turn around and you will find it. That matches the way that real people seem to move.

The way we move and how we relate to the world around us is a result of being embedded in the world. It is actually part of our cognitive equipment of the worlds that we design as architects. That is why if you design something which is unintelligible and maze-like it can actually be disempowering of people; it is like having a lobotomy. That is one of the things that I am going to suggest is going on in Ikea. There is an old Australian saying which is 20 million blowflies cannot be wrong. Why do people go there? Well, £8 chairs or tables might have something to do with it – great value – but I think there is actually a deeper issue. Ikea is highly disorienting, everybody knows about it, everybody complains about that sense. By the time you have negotiated your way around that upstairs showroom and got downstairs to where

you can pick up a trolley you have wasted a large part of your shopping time. The retail people will tell you this is bad for customer relations and the customer experience, but then when you get to the market-place you are faced with pallet-loads of glasses which are reasonably designed, very cheap and they go into the basket along with the rest of your impulse buys. Something like 60 per cent of Ikea's sales are impulse; you go there for one thing and you come away with an awful lot else.

What is going on here is something like power exchange. Unintelligibility removes autonomy but you agree to go there, maybe under protest. Eventually you go there, your submission is the first part of that contract, you have delay, and eventual gratification in the impulse purchasing section (the market-place) and then you reach the queue. Danny Miller, the anthropologist, describes shopping as sacrifice; I suspect that this is actually shopping as power exchange.

My third example is actually getting a bit long in the tooth, but it is such an important one in terms of its clarity of showing some principles that I feel I must use it in this audience. This is a project which Space Syntax worked on, along with Simon Henley and also with Andy Budgen from Spacelab who was one of my Masters students at the time. It is an advertising agency and we were brought in to do some ethnography into what is going on in this space, but also to try and stimulate the client in the political discussions that were going on about what they should do next. We analysed the spatial integration of the building and how people moved about it in it. It turns out that movement relates to spatial integration very powerfully in buildings like this, that design matters for how people move. There is no great surprise actually in that.

There is a second thing here, however. If you are trying to design an organisation in which people communicate with each other, and not just communicate, but find other people useful; in which you try and maximise the utility of the human resources in your organisation, you need to find out about how they communicate. We developed a questionnaire in which everybody in the organisation is named and we asked everybody to fill in how often they see each person - daily to never on a one to five scale. We asked whether they find them useful in their work and whether they work with them directly. We found that the creatives for example, don't appear to be particularly useful to everybody in the organisation; there is a very tight relationship between how frequently they are seen and how useful they are found on average.

We have done this for a whole range of organisations and we discovered that the more spatially integrated organisations turn out to increase the mean usefulness of their staff to each other. As organisations segregate and isolate part from part, the mean usefulness of staff to each other drops. Given that we spend far more on staff than we spend on buildings over the life cycle, this is important.

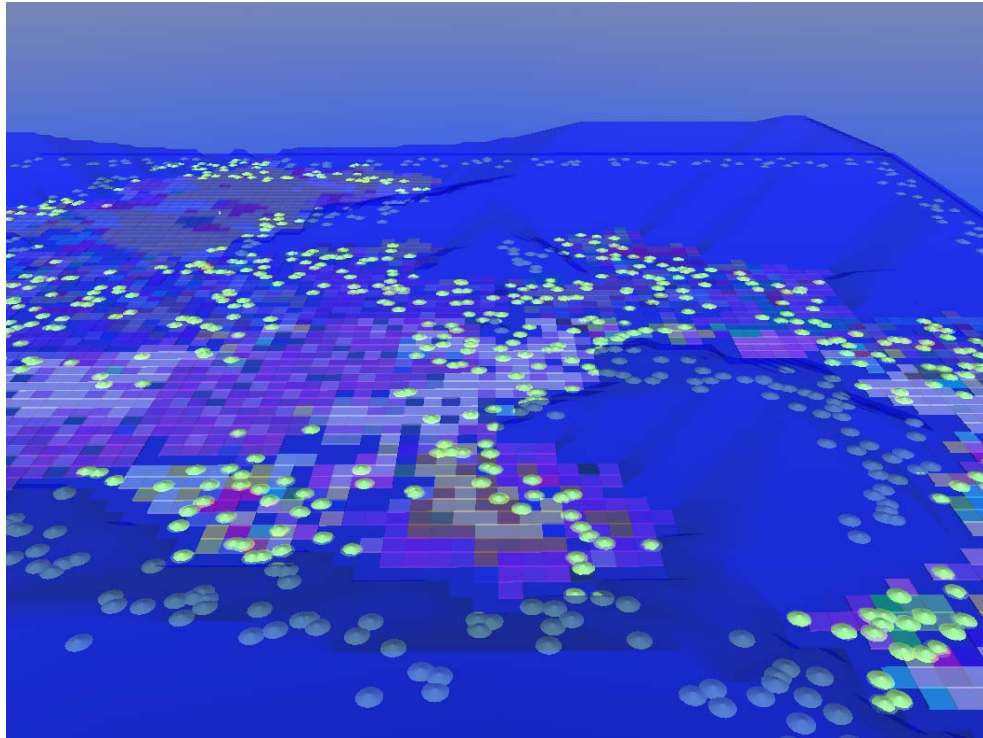
How do we know about this? We know about what is going on because Andy Budgen in his Masters degree took videos of how people worked in that building and coded them through time - a tremendously laborious piece of work in which he looked at how conversations take place. If you look at the micro structure of behaviour you find two things. The first is that as people move through the corridor system they are recruited into conversation if they catch an eye - people look up and they scan from their desks. Equally, people walking past look down and scan the desks. If two sets of eyes meet, occasionally a conversation takes place; usually it lasts less than 30 seconds but something like 80 per cent of work-related interactions seem to happen in that way, when it is essentially unplannable and unplanned.

Where do I work? At home I work in the dining room. I am surrounded with stuff; bits of personal history and so forth. The story of who we are, what makes us socially meaningful, is partly bedded in the environments we create around us and the objects we surround ourselves with. Where I work at work is much messier. Illustration 3 shows that on the wall in the research lab is a screen, it is a projector that is always on and what I am seeing is a projection of one of my PhD students who happens to be in Nottingham. We have been running this for the last year and a bit, it is always on. You can navigate your way with a little joystick up through a virtual environment – it is a bit of game space if you like.



*Illustration 3: a projection of one of my PhD students in Nottingham*

It is a virtual space which is now acting as an extension to my bit of physical space, I can see and communicate, but I can also adapt it and I can construct something in that environment which is beginning to make things meaningful to me. Instead of surrounding myself with material objects, it is communication links to other places and other people. One of the pieces of research that we did a little while back was to look at how you could take the knowledge that we surround ourselves with, the documents that sit on our desktops and with which we work in most knowledge-based work, and construct virtual landscapes which are potentially meaningful to people (shown in illustration 4).



*Illustration 4: The TOWER virtual landscape is composed of blocks representing the knowledge resources of an organisation. Proto-urban aggregation processes make the landscape meaningful to users.*

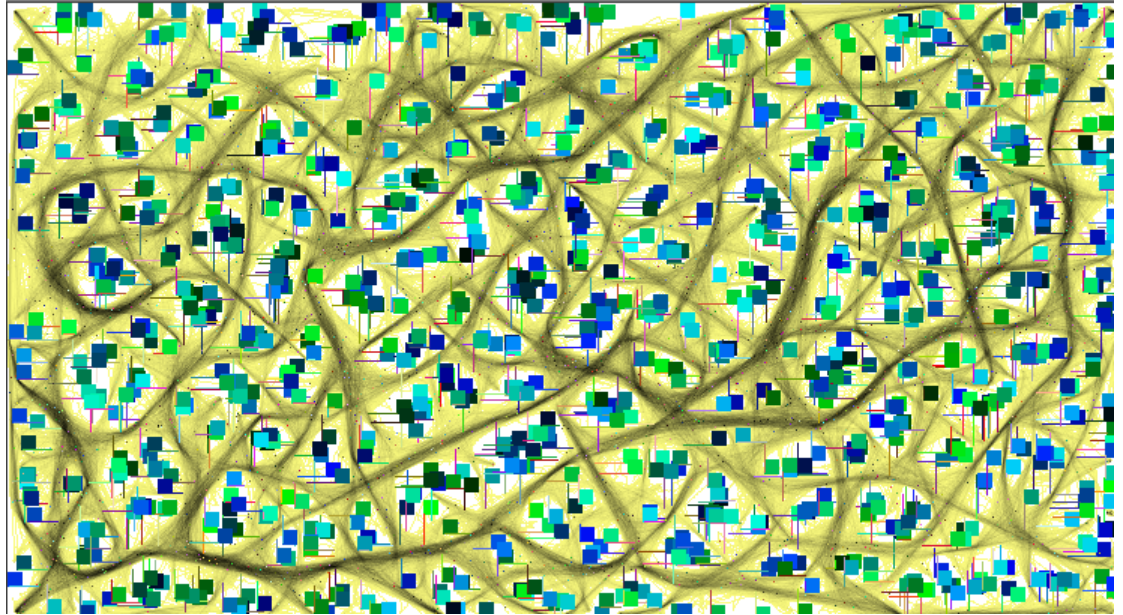
We trawled up some of the very early work that Bill Hillier did when he was starting out on Space Syntax-type work in which he tried to generate hill villages in the south of France. He goes to the south of France on holiday and is fascinated by the hill villages and asks how it is possible to generate these villages through a distributed process of design, one in which there is no top down designer. We go to them and we think they are wonderful, then we try and build them in north London for housing estates and they become social disasters. How is that process of village design taking place?

His proposal was that it is a rule-restricted random process of aggregation. We have taken that rule-restricted randomness to allow an environment in which every time you create a document, or change a document on your desktop, other people in the world can have a look at it and it can be placed in a location relevant to the other documents so that you know where to go to look for particular things. You want to make landscapes in the virtual world meaningful for human use; this is difficult, we have not solved it yet.

New technologies radically extend the range of architectural possibility. The construction of these sorts of landscapes in the virtual world, which remain and evolve over time, allow us to communicate across space and time. It seems to me that the new technologies are something which really challenge the frontier of what we consider to be architecture. Architecture has always dealt with these issues but it seems now that we are actually the people who have the knowledge and the understanding of the design process, the tacit know-how to engage in driving these things forward.

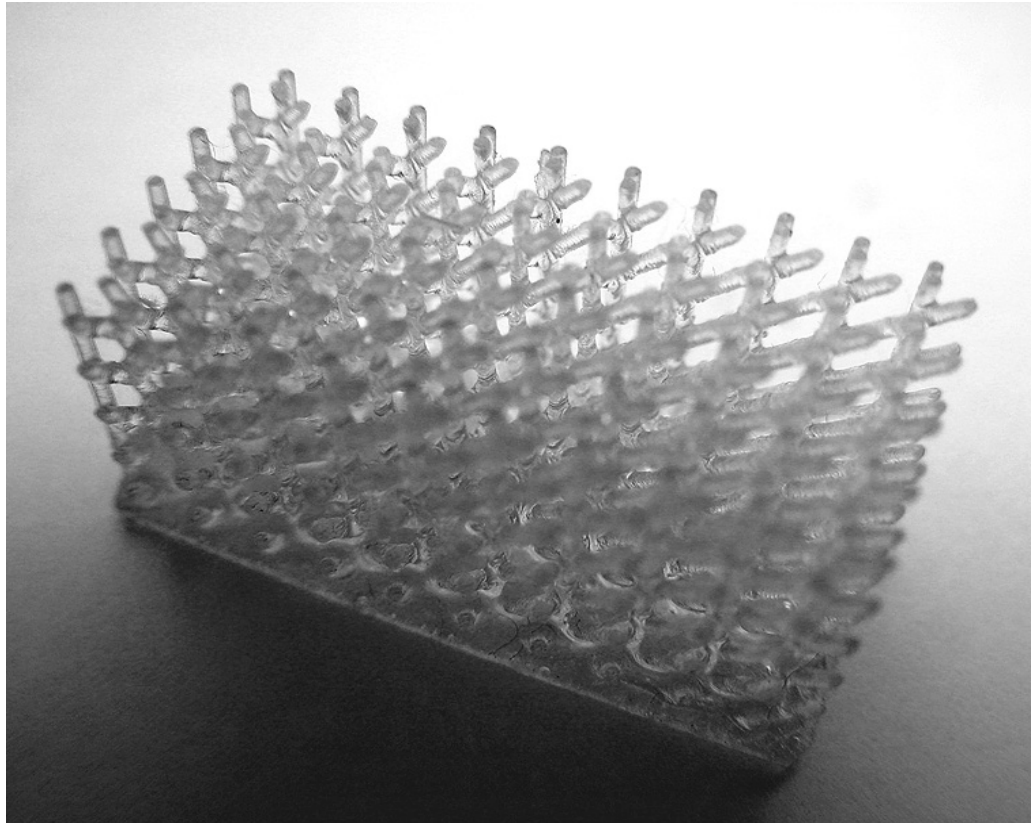
We have been engaging in this sort of village design. This is a very simple economy in which you have a whole village of shop-owners and they allow their computer agents

to buy from them and if not enough agents buy they go bust; you end up with a very intriguing pattern of space. Why are we doing this? We are doing this because we are engaged in sustainability research, funded by the EPSRC, and what we need to put a handle on is what economic sustainability means and how you make the economics of the city work in such a way that the environmental aspects of sustainability do not become politically unacceptable. We have to be able to handle both the economics, environmental and social aspects of sustainability all at once if we are going to try and make viable solutions into the future. Part of that is being done by essentially playing games.



*Illustration 5: A simulated proto-urban settlement generated using pedestrian agents with vision and an elementary retail economy*

The work that Shaun Hannah is doing in his engineering doctorate, sponsored by Fosters, is taking a similar sort of approach but applying it to structural optimisation. Illustration 6 shows a little rapid prototype, a 3D stereolithographed object, which is a structure that has been evolved to be optimal in terms of its strength under particular forces and is evolved by means of a very simple genetic algorithm. This sort of work allows us to make bridges between what is interesting in practice, interesting in the social world and interesting to academia.



*Illustration 6: An optimised structural lattice produced by driving a rapid prototype stereolithographer as part of a genetic algorithm loop.*

Finally, I am going to show you a link into the way that we actually design. This is a European project in which we were working with Fosters and Linnefear of Aachen, on the use of virtual reality, but using augmented reality glasses shown in illustration 7. The spectacles that you put on project the image of the world out there in front of you on the tabletop. We are getting a third person's view of what the other two are seeing as they work in this space.



*Illustration 7: The ARTHUR augmented reality designers table*

When we injected our pedestrian agents into the tabletop situation around which people were working, we found some very interesting things happening. When you take real time simulation and put that into the space which people are actively reconfiguring and changing, using the ability to interact with additional stuff, something quite interesting happens, and we did a little set of experiments. First we got our group of experimental people to work with matchboxes and construct something. People looked down at it from above and they made patterns with their matchboxes. Then we threw them into the virtual version of this where they had had the same sorts of shapes and objects and they could just manipulate their location. We found that they started to herd the little people and they began to collaborate much more as you would expect hunters to have collaborated in Neolithic times. They started to herd and block things off and channel people in particular ways. What you see happen though is that the pattern disappears; rather than trying to make symmetrical patterns they come up with alignments of built form and space which are about informing the way that things move. We then took them out of the virtual reality again and stuck them down with the matchboxes, the real physical things, and you could listen to their conversations, you could understand what they were talking about. Their perceptions had changed, so understanding directly the way that the agents moved made them focus on spatial pattern and on how people would use space rather than focusing on, if you like, ordered pattern or symmetry from above. There was an interesting change, and so what you could say is that this sort of engagement with real-time stimulation and the ability to manipulate form in real time actually appears to have an effect on the way that designers think about problems.

We found that in the original way that people worked, just working with a physical model, there were leaders and followers; somebody would say “Let’s do a swastika” and they would make a swastika, or “Let’s move that onto a diagonal and see what happens” and the collaborating partner would follow. The herding of agents happened as a result of a joint objective that did not really need to be talked about because it was to do with the third party. The agents move through the space, and all of a sudden people could become collaborators in a completely different form. Rather than a hierarchical form of top down leader and follower it became collaborators intervening in a world – like children playing and damming streams - they do not need to talk much, they just do it and they get together to make it happen.

We are experimenting with that set of ideas at the moment, partly through collaboration with Meta Thompson, Carol Brown and my colleague Karen Mottram. They have been working on dancers in dance performance with computer-generated agents. The agents respond to camera views and what the dancers are doing, the dancers respond to projections of what the agents are doing. Is it possible to dance architecture? Apparently Elvis Costello, during an interview about his music, talked about music being like dancing architecture. It raises a very interesting question. One of the things that we do as architects when we design is to work as intensely individual creators. We externalise our thoughts by the way we sketch, the way we build models. That externalisation, as Frank has said, is all about reflection in action, it is all about how we become reflective practitioners. That externalisation also allows us to talk to others, so other people looking over our shoulder at our sketch will grab the pencil and add to it and respond to it, but there is definitely a leader/follower pattern to the interactions. Somebody always has to draw the first line.

I am intrigued with the idea that in certain other time-based forms of media – in jazz, in dance and in various parts of performance – the creation of form is actually much more collaborative. You swap between leading and following and at some stage you

actually lose who is leading and who is following in the act of performance. That is an intriguing idea. As real-time simulation, based on explicit scientific knowledge of the way that the wind blows or the way that people move, becomes a reality, will we need to start to adopt methods of working in design that are based on those used in time-based media? Will we need to train our architects and designers in different ways of working together and collaborating in order to take advantage of the new technologies that allow real-time prediction and calculation? It is an intriguing idea and it is the sort of thing that I will go off and try and get some funding out of the Engineering Research Council for and we shall see what happens. I think that it is actually the link between architecture as research and architecture as practice that makes that type of intriguing thing possible. It is actually only when these new technologies become culturally of interest that they really begin to generate any value.

Computers are already embedded in the environment all around us, but as they become more and more pervasive and they get coupled to sensors and actuators in the world, (not just on automatic doors, but to things which reconfigure the physical building and the physical built environment) it seems to me that we have to explore the field of what becomes possible with those types of dynamic environment. It is only because we can understand the dynamics of the medium that we are going to be able to go on to develop theories, to explain simulations to predict its likely consequences. The education of designers becomes absolutely vital in this; we have to educate people to become reflective practitioners in a new and vastly expanded range of media. If we slink back to being only interested in the solid physical stuff and leave the rest to systems engineers, we are missing one of the most important transitions taking place in current culture. I do not think there is a risk of that though because what I observe is that young architects are going off and working for the mobile phone companies, they are going off and working for the computer companies. They are working all over the place and that is because design thinking and the tacit know-how of design is what is required in order to be able to exploit these technologies to their extreme. Those companies understand that, so I have no great fears. Whether or not they will be regarded as part of the profession is another matter and that is the place where the RIBA needs to make some moves and needs to think thoughts as fast as the rest of the world.