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UCL ENVIRONMENT INSTITUTE



# Forum

## **UCL RESIDENCY REPORT: Performance Piece on Climate Models**

The UCL Environment Institute Seminar Series Report





# **UCL Residency Report: Performance Piece on Climate Models 2011**

Report by

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**N.E.D.**  
*Nurturing Evolutionary Development*



## UCL Residency Report

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## UCL Residency Report

### 1. INTRODUCTION

This is a presentation of the results of my creative research residency at University College London. Since June, I have been working at the UCL Environment Institute, examining different forms of modelling. My research has included looking at predictive climate simulations, participatory models for communities and governments, integrated assessment models, and the processes through which these scientific tools are translated into public policy and decision-making.

This research is the first phase of the development of a new theatre work, which will be developed over 2012-13. This work will be constructed in the form of a participatory model, which audiences will be able to engage with to develop a deeper understanding of a series of interconnected real-world phenomena, and use to reach a stable consensus as the basis for coordinated action.

This report presents a summary of the research I have conducted, with the support and advice of UCL scientists, and outlines the proposed format for the development of a new interactive work based on this research.

#### 1.1 David Finnigan bio

I am an Australian playwright, theatre producer and festival director. Since founding science-theatre ensemble Boho Interactive in 2006, I have developed a reputation as a significant emerging science/arts practitioner. Boho's Game Theory-based play *A Prisoner's Dilemma* presented seasons in Adelaide, Brisbane, Canberra and the Gold Coast, including at the 2007 Asia-Pacific Complex Systems Science Conference. In 2009 Boho was funded to complete a residency in the Manning Clark House Cultural Centre to write and produce *Food for the Great Hungers*, a performance exploring Australian history and complex systems science. In 2010, Boho was co-commissioned by the Powerhouse Museum to produce and tour *True Logic of the Future*, an interactive science-fiction performance exploring issues of Climate and Global Change. Boho's collaborators include scientists from CSIRO's Centre for Sustainable Ecosystems, the Powerhouse Museum and the National Centre for Science and Technology (Questacon).

With Boho, I have developed a diverse set of styles and techniques for live interactive performance. Building on pre-existing forms ranging from street performance, live art and computer gaming, Boho employed different techniques to elicit varying forms of audience participation and contributions. Over 2006-10, Boho developed and tested more than 15 unique interactive performance formats. This array of forms include a broad spectrum of interactive mechanisms, performer/audience relationships, passive/active involvement, narrative/experiential performances, individual/large-scale audience involvement. Having consolidated this 'menu' of functioning mechanisms, I am now seeking to apply them to the field of participatory co-modelling.

Boho can be found online at [www.bohointeractive.com](http://www.bohointeractive.com)

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### 1.2 Purpose of residency

Over 2009-10, Boho's work increasingly touched on models, and as a company we incorporated models into our shows (e.g. Per Bak's sandpile model of self-organised criticality). Following our 2010 show, I decided to pursue this interest further through a dedicated period of research.

I received funding through the N.E.D. Foundation's Social Development Network to undertake a three-month creative research residency at the UCL Environment Institute of University College London. Working with Dr Yvonne Rydin and other UCL researchers, I explored a range of different modelling practices and UCL's inter-disciplinary report *Building Health Into Cities* as the content for a new model-based interactive performance.

## 2. MODELS

### 2.1 What is a model?

A model is a mental or formal representation of a system which is used to anticipate its future behaviour. When we store information from the past and use it to predict the behaviour of the future, we are modelling.

Modelling is a universal activity. All living creatures store information from the past and from it extract regularities. These regularities are a model of the environment which that creature uses to anticipate the future.

'Whether it is a tree responding to shortening day length by dropping its leaves and preparing its metabolism for winter – in advance of winter – or a naked Pleistocene ape storing food in advance of winter for the same reasons, both are using models.'<sup>1</sup>

As Joshua Epstein points out, 'Anyone who ventures a projection, or imagines how a social dynamic - an epidemic, war, or migration - would unfold is running some model... when you close your eyes and imagine an epidemic spreading, or any other social dynamic, you are running some model or other. It is just an implicit model that you haven't written down.'<sup>2</sup>

Because we all use models to help imagine the future, the question is not 'Should we use models?' but 'How do different models compare with each other?' The difference, therefore, is between the internal explicit models which we create instinctively, and the explicit models that scientists use.

In the implicit models of reality which humans (and other species) construct internally, 'the assumptions are hidden, their internal consistency is untested, their logical consequences are unknown, and their relation to data is unknown.'<sup>3</sup>

An explicit model is one which is written down so that it can be shared, discussed, and tested against data. Assumptions are stated, and can be altered if required. The model can be calibrated to historical cases and tested against current data. Also, an explicit model enables you to incorporate opinions and expertise other than your own.

This paper will focus on various forms of explicit models.

<sup>1</sup> Boschetti F, Fulton EA, Bradbury RH & Symons J, 'What is a model, why people don't trust them and why they should'

<sup>2</sup> Epstein JM, 'Why Model?', published online at www.mit.edu

<sup>3</sup> Ibid

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### 2.2 What are models for?

There are a number of reasons to construct models. Every scientist who creates a model will have a different specific goal or set of outcomes. However, most models are constructed to achieve one or more of these goals:

- **Prediction** - To create predictive scenarios that allow us to prepare for the future;
- **Understanding** - To illuminate the workings of the system being modelled;
- **Training** - To teach skills and attitudes useful for dealing with complex systems.

#### Prediction

Models are frequently used to predict the future behaviour of systems. Most famously, climate and weather simulations use current meteorological data to make predictions about climate and weather in the future. These models have become a vital part of our everyday life, and a key tool in the effort to understand the phenomenon of climate change.

Other predictive models attempt to anticipate the behaviour of the stock market, of social trends or of the spread of disease, with varying success.

Importantly, predictive models rarely allow us to anticipate an exact behaviour or event, but rather an estimation of its likely limits. Geophysical models, for instance, cannot predict accurately where and when large earthquakes will occur, but they are able to predict the geographical areas in which large earthquakes can be expected. As Bradbury *et al* point out, 'while this kind of predictability seems to offer little to planning, it still has considerable practical impact on deciding where anti-seismic construction methods are practical and where they are not.'<sup>4</sup>

Typically, predictive models produce scenarios. By simulating the activity of a system over multiple realisations, they are able to generate a range of possible future outcomes and can distinguish between likely and unlikely scenarios.

In this way, rather than providing one picture of the future, models offer us a range of possibilities. By altering the assumptions and parameters within the model, we can examine the ways in which the future is locked in or changeable.

This allows us to view both the best and worse case scenarios, and to compare the likelihood of different outcomes. Although this is not an infallible fortune-telling device, a well-constructed model can be an invaluable tool for predicting and responding to the future.

As Pascal Perez puts it, 'We use models as tools to reduce uncertainty.'<sup>5</sup>

<sup>4</sup> Boschetti F, Fulton EA, Bradbury RH & Symons J, 'What is a model, why people don't trust them and why they should'

<sup>5</sup> Perez P, 'Science to inform and models to engage'

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### Understanding

Whether or not they produce reliable predictions of the future, models can be valuable aids to understanding the ways in which a system functions.

Building a model of a system entails making assumptions about the important components of that system and the relationships between them. Checking the model's behaviour against the behaviour of the real-world system is a good way of testing the veracity of your assumptions.

Karl Popper asserted that science proceeds by framing hypotheses which can then be falsified by comparison with observations. When we deal with complex systems, especially if societal dynamics are involved, building a model may be the simplest or only way of framing a hypothesis.

For instance, a new climate model will be given a set of starting conditions from the past (e.g. 1960) and then run forward to the present. If the model's predictions for the period 1960-2010 are vastly at odds with reality, then there is a good chance that the model has not captured the important aspects of the climate system. In this way, even without attempting to predict the future, models can be valuable guides to understanding.

Joshua Epstein's 'Why Model?' lists a variety of other ways in which modelling can improve our understanding of the systems we model: they can guide data collection, illuminate core dynamics, suggest dynamical analogies, reveal new questions, illuminate core uncertainties and challenge prevailing theories through perturbations.<sup>6</sup>

### Training

#### Facilitating communication

One issue faced by people seeking to study and respond to complex problems is that people often enter into dialogue with their opinions and attitudes already fixed. Francis Bacon argues that innovative ideas cannot be introduced combatively, because people will disagree with them rather than suffer cognitive dissonance.<sup>7</sup>

In these situations, explicit models can allow for the engagement of different parties by providing an objective platform for debate, communication and collaboration.

One way in which this can occur is through demonstrating that the modelled consequences of some worldviews are clearly illogical or impossible, or that the consequences of different worldviews are incompatible and exclusive. This approach has been developed to a considerable degree of sophistication in applications to development and resource use at regional scale, where affected parties participate in model construction. In this participative approach, the act of model building can also be an act of problem solving and dispute resolution.<sup>8</sup>

As Bradbury *et al* point out, 'allowing a less biased interpretation of available information is important because people with different worldviews may interpret and draw very different conclusions from the same information.'<sup>9</sup>

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In this way, models can bring together groups of people from varied backgrounds and disciplines and enable them to constructively engage with one another.

#### Provide people with useful cognitive attitudes

As well as facilitating communication between people from various backgrounds, models can also serve to educate policy-makers and the general public by promoting a scientific state of mind.

Bradbury *et al* argue that 'managing and predicting complex behaviours can be learned and that models can represent systems in a manner appropriate for learning and training.'

Engaging with models of complex systems can enable individuals to understand processes of real world significance better, such as the management of limited resources and unexpected feedbacks.<sup>10</sup>

From this standpoint, models can be seen as 'flight simulators' for decision-makers, offering the opportunity to make mistakes and experiment safely with ideas in a virtual space.

Alongside these cognitive skills, Bradbury *et al* list a variety of cognitive attitudes, crucial to effective decision making, which can be identified and trained via models. These include the ability to interpret outcomes against expectations, to balance emotional responses (e.g. humility, curiosity, frustration and blame-shifting), to tolerate high levels of uncertainty, acknowledge mistakes, to search for counter-evidence and to usefully self-reflect.<sup>11</sup>

The potential for models to improve training programs for policy-makers could have a substantial impact on a variety of real-world issues.

#### Assist in formulating responses to complex problems

Models can also assist in formulating responses to specific problems and crises. An appropriate model can offer crisis options in near-real time, demonstrate trade-offs, suggest efficiencies, and help keep the dialogue focused on priorities.<sup>12</sup>

Models of physical processes play an important role in planning the use of finite resources like water and primary energy. Demographic models and projections are fundamental inputs to much government infrastructure planning. Economic modelling has become an essential part of national and international planning in areas like tax, trade, overseas aid and development and intergenerational equity. Led by organisations such as the IPCC, social, economic and climate models are now combined in Integrated Assessment Models (IAMs) to trace feasible trajectories through the maze of complex choices posed by the need to mitigate and adapt to climate change.

All in all, models now provide indispensable reference tools for policy-makers. Organisations such as University College London and CIRAD are exploring ways to engage policy-makers with the theory and practice of systems modelling.

<sup>6</sup> Epstein JM, 'Why Model?'

<sup>7</sup> Perez P, 'Science to inform and models to engage'

<sup>8</sup> Ferrand N, 'A Shared Room for Viability: Multi-level participatory pathways toward viability'

<sup>9</sup> Boschetti F, Fulton EA, Bradbury RH & Symons J, 'What is a model, why people don't trust them and why they should'

<sup>10</sup> Boschetti F, Fulton EA, Bradbury RH & Symons J, 'What is a model, why people don't trust them and why they should'

<sup>11</sup> Ibid

<sup>12</sup> Epstein JM, 'Why Model?'

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### 2.3 Types of models

There are numerous different types of systems models, ranging from the extremely simple to very complex. Bradbury *et al* identify five main classes of model, from toy models (simplified models in which only a handful of components are included, to clarify specific aspects of the system) through to full system models (which include all information collected for a region to address all scenarios of stakeholder concern).<sup>13</sup>

A larger model will often contain a variety of smaller modules within it or be constructed by linking together a set of specific process models; for instance, a modern Global Climate Model (GCM) would comprise an atmospheric model, an ocean model and a land surface model. These major components would, in turn have sub models to describe (inter alia) atmospheric chemistry, radiation, the carbon cycle, ice dynamics and so on.

The choice of model to build or use is problem dependent. The question is: what tools will give the most reliable prediction given the problem at hand?

In this paper, I will discuss three types of models: Global Climate Models, Agent-Based Models and Participatory Co-Models. While only a small sample, these case studies aim to give an idea of the range of different forms and purposes for which models are constructed.

### 2.4 Global Climate Models

There are numerous different types of systems models, ranging from the extremely simple to very complex. Over the last 25 years, Global Climate Models (GCMs) have become perhaps the most prominent and well-researched of all complex systems models.

These large-scale simulations are used to simulate the trajectory of the earth's climate over the coming decades.

In its periodic assessment reports, the Intergovernmental Panel on Climate Change (IPCC) compares the future climates predicted by a range of GCMs, each of which calculates the way the climate system responds to ranges of greenhouse gas emissions and land use changes. The latest assessment report, AR4, published in 2007, reported results from 23 GCMs from around the world. The IPCC assumed all 23 were equally valid and aggregated their predictions to create its scenarios.<sup>14</sup>

Each of these 23 GCMs is based on supercomputer models of the climate system, principally the atmosphere, the oceans (hydrosphere), the biosphere and the cryosphere. The physical (and to some extent, the biochemical) processes occurring in these 'spheres' are represented by equations and formulae resolved onto three dimensional grids, which determine the spatial resolution of the predictions. The model-makers enter the initial state of the system and the models solve the equations forward in time to simulate future climate trends.

All the models are compared with observations of past climate to calibrate them. By setting the starting conditions for the models as they were at the end of the last Ice Age, scientists can compare the models' predictions with the paleoclimatic data from the last 13,000 years. They can be tested with

<sup>13</sup> Boschetti F, Fulton EA, Bradbury RH & Symons J, 'What is a model, why people don't trust them and why they should'

<sup>14</sup> Maslin M, 'Global Warming: A Very Short Introduction'

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even more precision against the thermometer record gathered over the last 150 years. This calibration process allows the modellers to check the models' accuracy against the recorded reality and identify any significant discrepancies.

The GCM's require as input, the trajectory of greenhouse gas emissions and land use changes. To ensure that these inputs are realistic and internally consistent, a different class of complex system models, so-called Integrated Assessment Models (IAMs), are used to generate them. IAMs combine models of population growth and economic activity with simplified representations of the climate system and the carbon cycle to achieve this. Unlike GCM's, IAMs are able to rely upon basic physical laws to a much smaller extent and this makes the assumptions within them much more problematic and contested. Nevertheless, they are currently the best way we know to produce informed predictions of the key drivers of the climate system, the way this system will respond to mitigation policies and the kind of adaptations we will have to make to the changes that are inevitable.

Because so much of the future course of human society is contingent on imponderable human choices, bodies like the IPCC have generated consistent sets of future scenarios, which span ranges of conceivable futures for mankind and have then modelled these scenarios using IAMs to produce the emission and land use paths which result. Typical features distinguishing different scenarios are things like:

1. How global or how regional is the human economy? Do human societies continue to interconnect in the future, or does the economy fragment around a few major trading blocks?
2. How environmentally friendly will global society be?

Within these two given conditions different assumptions can then be made about global population and the rate and impact of technology and innovation.<sup>15</sup>

It is important to remember that the wide spread in possible future climates calculated by the IPCC owes rather more to the uncertainty in these socio-economic scenarios than to the chaotic nature of the climate system. For example, the 23 GCMs in IPCC AR4 simulate temperature increases in 2100 ranging from about 1.5 to 6.5 deg. C above pre industrial conditions. However, if the world continues on its present, business as usual emissions path, the predicted range is more like 4.5 to 6.5 deg. C.

Over the last twenty years, GCMs have become more and more sophisticated, for several reasons.

The models now contain more and more-sophisticated representations of the climate system. For example, earlier models concentrated on the atmosphere and its radiation balance and did not represent the oceans in a dynamic way. Earlier models also represented the terrestrial biosphere in rudimentary ways but now GCMs include sophisticated soil-vegetation-atmosphere transport modules as well as schemes to track how vegetation responds to climate change itself. Three current foci for process improvements are in ice dynamics and cloud processes and in models of the carbon cycle.

Other improvements have come from increases in computer power which have led to serious improvements in the ability of GCMs to simulate some processes which need to be resolved on fine grids such as ocean currents. Speedier computers also allow ensemble runs so that future climates can be presented as probabilities.

<sup>15</sup> Maslin M, 'Global Warming: A Very Short Introduction'

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Third, we now understand the dynamics of the climate system itself much better so that scientists have a much more comprehensive idea of how the models should realistically behave.

A current frontier occupying many modellers is the challenge of 'downscaling' results from GCMs to fine grids, so that local impacts can be assessed, and the merging of climate and weather prediction to give 'environmental prediction capability' on decadal timescales.

### 2.5 Agent-Based Models

Agent-Based Models (ABMs) are tools frequently employed to simulate large numbers of individuals interacting in a system. They are particularly useful for reproducing social dynamics.

Usually simulated on computers, agents are software entities which are given goals to pursue and certain attributes such as bounded cognition and rules which govern their interaction with other agents.

Muki Haklay describes a typical agent-based model as containing, 'several hundred agents interacting in an artificial world representing some real world location or social institution (a market, for example). The agent modeller programs agents with plausible rules governing their behaviour and examines model outcomes to obtain insight into the real world situation modelled.'<sup>16</sup>

ABMs have been used to model the spread of disease, the mechanics of bird flocking, racial clustering in urban environments, social trends and crowd behaviour.

Just as the real systems they are simulating, ABMs frequently exhibit the property of 'emergence' - the numerous interactions between individual agents combine to produce regular or predictable behaviour at the system level. An example is the phase transitions which take place in epidemiology models. As disease carrying agents interact with and spread infection to other agents, there is a gradual increase in the infected population. At a certain threshold, there is a sudden surge in the number of infections, and the disease goes from being a minor threat to an epidemic. The importance of this phase transition for policy-makers seeking to manage disease spread in society is critical.

One reason that ABMs have proved so useful in simulating social dynamics, whether it be the physical movement of crowds or the intellectual interaction which occurs in markets, is that the emergent behavior in these situations is usually strongly non linear, hysteretic, path dependent and, all in all, extremely difficult to capture in algorithms. In contrast, the rules of person to person interaction can be deduced from disciplines like psychology, experimental economics, game theory or anthropology and, when coded into the agents, the group or population level behavior emerges from their interaction in their silicon world.

### 2.6 Participatory Co-Models

The third type of model I will discuss is referred to by different names, including companion modelling, post-normative analytical modelling or, participatory planning models. I will follow Pascal Perez in referring to them as participatory co-models.<sup>17</sup>

<sup>16</sup> O'Sullivan D, Haklay M, 'Agent-based models and individualism: is the world agent-based?'

<sup>17</sup> Perez P, 'Science to inform and models to engage'

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Rather than focusing on precision in their simulation of real systems, participatory co-models aim to support collective learning and decision-making.

Co-modelling highlights the process rather than the outcome of the model. The aim is to involve the stakeholders who will be affected by the model's outcomes in the creation of the model.

Typically, scientists creating a participatory co-model of a system, such as a managed river system or an exploited ecosystem, will undertake repeated engagement with local stakeholders to bring in a broad range of specific expertise.

Perez points out: 'The subjectivity and contextual nature of the models is fully acknowledged as the observer is considered as part of the experiment... Furthermore, ComMod emphasizes the modelling process itself rather than concentrating on the model only, embedding information gathering, model design and use of simulations into a collective process.'<sup>18</sup>

The participatory co-model identifies and makes explicit the various viewpoints and subjective criteria to which the different stakeholders refer implicitly or even unconsciously (CIRAD).

Accommodating many different perspectives and opinions on the nature of the system in question guarantees that the model will have limited capacity for prediction.

However, the advantage of this approach is that the model has been socially validated by a wide spectrum of stakeholders, and consequently can be used as a legitimate platform for decision-making.

As Perez puts it, 'This means a compromised process but better uptake and more likelihood that the recommendations will be used.'<sup>19</sup>

The CIRAD ComMod Charter describes three kinds of tangible effect the participatory co-model can achieve: '1) modification of players' perceptions, 2) modification of the way they interact, 3) modification of the actions taken.'<sup>20</sup>

Though all types of dialogue between the researcher and the stakeholder can be considered in participatory modelling processes, more formal approaches focus on the construction of an explicit model; a map, an information system or a computer model.

An example of a participatory co-model is Garcia Barrios *et al's* MESMIS project, which focuses on ecosystem management in rural Latin America. In one iteration of this model, stakeholders from a Mexican river-system were invited to take part in a co-modelling process.<sup>21</sup>

These stakeholders included a maize-farming community from along the river, tourist operators from the nearby lake, and local government officials. Representatives from these three groups joined scientists for a three-stage modelling exercise.

In the first stage of the model, the participants explored the situation of the maize farmers, who were seeking to increase the yield of their land by introducing a new fertiliser. By experimenting with the model, participants discovered the quantities of fertiliser required to sustain the members of this community.

<sup>18</sup> Ibid

<sup>19</sup> Perez P, 'Science to inform and models to engage'

<sup>20</sup> ComMod Association, 'ComMod: A Companion Modelling Approach charter'

<sup>21</sup> Garcia-Barrios LE, Speelman EN & Pimm MS, 'An educational simulation tool for negotiating sustainable natural resource management strategies among stakeholders with conflicting interest'

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In the second stage of the model, the participants took on the role of the tourist operators on the downstream lake. The model demonstrated the impact of fertilizer run-off on the lake ecosystem, and consequently the value of the land for tourism. By experimenting with the model, the participants explored the safe quantities of fertilizer which could be added to the river system in order to sustain the tourist industry.

In the final stage, the participants took on the role of the local authorities, seeking to balance the demands of the two communities with the complex behaviour of the ecosystem.

Barrios *et al* report that throughout the dramatization, participants tested out a variety of tactics and solutions, including trying different problem-solving attitudes (e.g. the strongly involved versus the unattached; the patient versus the impatient; the optimist versus the pessimist, the rule-follower versus the rule-breaker, the detail-oriented versus the big-picture-oriented, the negotiator versus the conflict escalator).<sup>22</sup>

The result was a consensus agreement on the best approach to managing the river system for all concerned. As is almost always the case, the consensus was also a compromise which did not deliver the optimum results for any single group but the best results that all three could accept.

This form of modelling provides an interesting array of opportunities for artists exploring the potential for connecting modelling to performance.

### 3. PERFORMANCE

The purpose of this project is to develop an interactive performance based on models, particularly participatory co-models. Following the initial research period in 2011, the work will be developed over a devising/workshopping period in 2012, with the aim of presenting a touring season in Australia and the UK in 2013.

#### 3.1 Why make a performance about models?

The motivation to explore modelling through interactive performance has developed from a few key impulses:

- Plays and performances are in their own way forms of models - they are 'what if' scenarios that allow us to observe and consider particular aspects of our world in isolation - this project came from a desire to acknowledge these parallels and take this relationship further.
- Scientists (especially participatory co-modellers) use elements from theatre and the arts when creating models, including visual representations of systems, roleplaying techniques and interactive performance tools. It is worth exploring what the arts might be able to take from modelling practice.
- Models have been extremely successful in examining and revealing aspects of our world - including elements of human ecosystems and social systems - and these results have had a genuine impact

<sup>22</sup> Garcia-Barrios LE, Speelman EN & Pimm MS, 'An educational simulation tool for negotiating sustainable natural resource management strategies among stakeholders with conflicting interest'

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in terms of policy and public understanding. The arts should be seeking to have a similar kind of public impact by allying itself with these rigorous forms of representation.

- Boho has previously used models in its performances, in particular in the 2009 show *Food for the Great Hungers*, and in Boho's 2011 TEDx lecture. The effectiveness of models as both theatrical devices and explanatory tools suggested the value of pursuing this exploration further. Boho's work up until this point has focused on creating live Agent-Based Models - for instance, the live presentation of John Conway's Game of Life at the TEDx Canberra lecture. However, the field of participatory co-modelling offers great opportunities to fully capitalise on the unpredictable complexity of live human input, rather than simply using humans to mimic software agents.

#### 3.2 Performance objectives

There are three key objectives for this performance. The first is to explore the ways in which a participatory co-model format might translate to interactive performance to test out the theatrical possibilities of this form.

The second is to introduce different audiences to the concept and practice of modelling, through a practical engagement with a participatory co-model. Through seeking to manage a system in the context of a model, audiences will develop an awareness of the strengths and limitations of this tool, which is of great value given the ubiquitous presence of models in the world today.

The performance will also teach some of the cognitive skills and cognitive attitudes that participatory co-models are able to convey. Through the performance, the audience will experiment, explore and learn to manage a complex system. In the process, they will learn lessons such as:

- Complex systems are interconnected;
- Actions can have unpredictable side-effects;
- How to search for counter-evidence;
- How to tolerate high levels of uncertainty;
- The importance of acknowledging mistakes and frequently reassessing assumptions.

#### 3.3 Sample performance

The structure and content of the performance will be created through a development period in 2012. However, as a guide for readers unfamiliar with interactive performance or live gaming, here is an example of the kind of work that may result:

A playing audience of 10-20 participants are presented with a representation of a complex system, e.g. an urban community at the scale of a city block. This is represented through projection or a physical model of some kind.

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The inhabitants of this community are facing some kind of issue; for instance, high crime rates. The audience are able to manage this particular area of the system through an interactive mechanism of some kind. They can adjust parameters (for instance, the number of police patrols through the areas) until they have solved the issue.

Having solved this problem, they find that the solution they have imposed has led to unexpected side effects on other parts of the system. For instance, increased police presence may have resulted in traffic congestion and raised prices.

Through multiple interactive mechanisms, the audience are able to adjust a range of different parameters to reach a compromise in which the different components of the system are able to function in a stable and satisfactory state.

### 3.4 Development process

The first stage of the work was a creative research residency from July - November 2011. This residency provided a practical grounding in contemporary modelling practice, and potential content for the work in the form of UCL's *Building Health Into Cities* report.

The next stage of the process is a 4-5 month creative development from July - November 2012 to build the work based on the outcome of the research residency. David and Boho Interactive associate David Shaw will travel to London and work for a period with two UK artists, a designer and facilitator. The development period will focus on devising and workshopping a performance according to the Battersea Arts Centre's scratch process. Through a series of work-in-progress showings, different elements of the performance will be explored and tested, leading to a first-draft performance at the end of November 2012.

Through this process we will seek to answer the following questions:

- What kinds of systems can a theatre model represent? (e.g. ecosystems, communities, trade / economic systems, social groupings);
- What scale is the most effective for this kind of work? (e.g. a river system vs. one lake, a city vs. a city block, a society vs. a small community);
- How best can we visually represent this system? (e.g. digital projection, table model);
- How can we integrate performance with facilitation? (e.g. what storytelling / theatrical devices are most effective in this context);
- To what degree is the performance a participatory workshop activity versus a staged performance with interactive components? (e.g. is it a theatre performance with several interactive inputs, or a workshop event with performance elements);
- What input do the audience / participants have into the system? What can they change, and to what degree?

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- How do they enact this input? What are the interactive mechanics? (e.g. voting, computer controllers);
- What is the ideal audience size for this work? What context can it fit in? (e.g. schools, festivals, conferences);

### 3.5 Timeline

The proposed timeline for the development of the work over 2012 is as follows:

July 2012	David and Boho associate David Shaw arrive in UK, begin working with UK designer and facilitator;
August - October 2012	Artists experiment and develop material for regular scratch showings;
November 2012	Final scratch of work for invited audience, touring partners and supporters sought for production;
June - August 2013	First production of the work in UK / Australia.

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