Simulating Our World

Adventures in agent based modelling

Trainer's Notes

BY NC SA

COMPUTING AT SCHOOL
EDUCATE · ENGAGE · ENCOURAGE
Part of BCS, The Chartered Institute for IT

Background

Despite modelling being a requirement from the previous ICT curriculum, few children will have any experience of building models beyond simple spreadsheet simulations. Deterministic models are difficult to construct due to their complexity, though there is much value in exploring existing predictive models and appreciating their widespread application.

By contrast dynamic, decentralised systems (which predominate in the natural world) offer plenty of scope for developing modelling capability. What distinguishes these types of models is that they involve many agents interacting, following simple rules, from which group behaviour emerges. Modelling environments exist, developed specifically for education, that allow large numbers of agents to execute simple instructions in parallel. They make model building accessible to students at Key Stage 3. The models involve a random element so are unpredictable. Often the aggregate behaviour that emerges from programming very simple individual rules is highly motivational.

This session is designed to introduce teachers to core ideas about agent based modelling and give them practical experience of modifying existing models. The core challenges are supplemented with a range kinaesthetic activities to build awareness of decentralised systems. By the end of the session, attendees will have been exposed to two well known modelling tools, one block based (StarLogoTNG/Nova) and one text based (NetLogo).

The aim of the day

The aim of the unit is summarised in the learning objectives for teachers. The primary aim is to ***educate teachers*** and illustrate the breadth and depth of Computer Science. The specific outcomes ***for teachers*** from this unit, are to:

- Be able to distinguish between different types of models.
- Become familiar with the basic concepts involved in agent based modelling.
- Identify connections with other subject disciplines.
- Investigate exercises illustrating ‘emergence’.
- Be familiar with a framework and pedagogy involved in getting to grips with modelling.

Ultimately, we hope they will leave inspired to introduce some of these key ideas at KS3

The purpose of this Tenderfoot session is to equip ***trainers*** with material and ideas to meet these outcomes and broaden the outlook of teachers new to Computing. It hopes to provide a buffet of resources on which teachers can draw, to enrich their Key Stage 3 lessons, at the same time as meeting the key aim: providing greater depth of knowledge for ***teachers*** themselves. Developing ***teachers*** is the focus, not providing activities for pupils.

Throughout the material there are references to computer scientists and educationalists and lots of pointers to other material. The aim is to encourage teachers to delve deeper and take the ideas further.

Before delivering the unit, please check you are comfortable with the narrative and references to other material. This is predominantly a practical session looking at exemplar programs. Some of the material is complex and requires thorough preparation beforehand and familiarity with the environments and programs. There are teacher’s notes which include a detailed summary of each activity. Ensure you rehearse the delivery to familiarise yourself with transitions and animations. Where it is required, the slides include further notes.

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Keep in mind the main purpose of the session – to engage experienced teachers with some of the deeper ideas in Computer Science they may not be familiar with. This sort of background knowledge is broadly 'A Level' standard. In time, all Computing teachers should have this grounding, so the aim is to empower the experienced teachers, providing them with material they can deliver and use with less experienced colleagues in shorter training sessions.

There are lots of exercises and supplementary activities. The software used will likely be unfamiliar to most attendees – do consider this when planning. The pace should be fast, with the assumption that the audience are experienced teachers, probably already teaching to GCSE level, with some familiarity with the concepts of Computer Science. As such they will not need to work through every activity in full but time may be required for software familiarisation. Sometimes it will be sufficient to part complete an activity so teachers 'get it' and can discuss how it might be used. Judgement is required and the timings below are indicative, to help with planning. Always be flexible and encourage discussion and engagement. Details of each activity are given in the teachers notes. Further guidance on the narrative, slide transitions and animation can be found in the slide notes.

Indicative Timetable

The trainer's presentation is broken down into 5 sections, with several formal inputs and 5 main practical activities outlined below:

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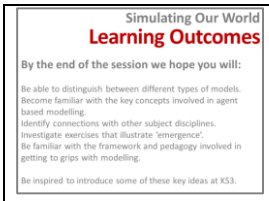
<td> 

10 minutes</td>
<td>Establishes key outcomes from the day for teachers (5 mins).

Sets the session in the context of the key educational goal: developing computational thinking and associated concepts.

Introduces a sample model that is the end goal of the session. (3 mins).</td>
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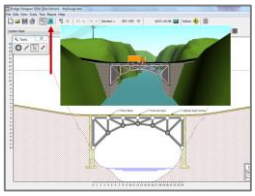
30 minutes</td>
<td>Introduces framework: Use – Explore – Build and defines analytical models.

Brief exploration of Bridge Design to illustrate opportunities analytical models give to <u>use</u> models to investigate problems. Offer limited possibilities for <u>exploring</u> rules. The rules to determine aggregate behaviour are usually beyond students at KS3.</td>
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120 minutes</td>
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 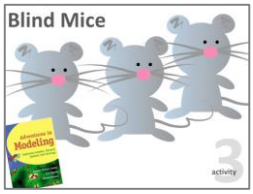

A lengthy session which could be split into 2, one hour blocks.

Hungry Turtles familiarises group with StarLogo (45 mins). Round of Applause kinaesthetic activity (10 mins).

 

African Plains paired code reading (30 min).

Blind Mice outdoor activity (25 mins).</td>
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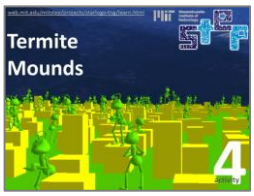
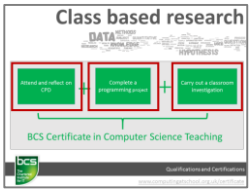
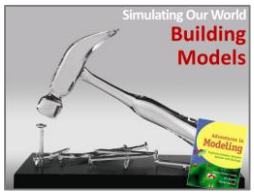
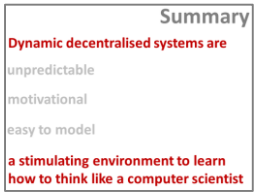
 60 minutes	Introductory video (10 mins). Discovering termite rules activity (20 mins). Termite coding and explanation (25 mins) introduces subsets, changing terrain height, colour of agent and Boolean functions. 
 60 minutes	 Epidemic (30 mins) talks through investigation of code, with attendees at computers. Needs to be brisk – once code explained key point is output and eventual consideration of parameter sweeping.  Sheep Wolves (30 mins) introduces text based code and NetLogo. Another walk through, with practical exercise to implement a parameter sweep and set up behaviour space.
 10 minutes	A short discussion to promote classroom research and encourage reflective practice. Draw out suggestions for potential research areas and mention possible techniques. Ends with a quick promotion of the BCS Certificate in Computer Science Teaching. 
 60 minutes	Paper catchers activity (15 mins) followed by exploration and analysis of Undersea World code (15 mins). Practical time for completing code (30 min) could be left if time is short. 
 5 minutes	Final summary emphasising connection between the development of technology, key concepts and computational thinking. (5 mins).

Above all else, remember that the aim is to empower attendees to offer similar sessions to colleagues. It should be inclusive, enjoyable and embody the CAS ethos of collegiality: There is no 'them', only us!

When someone books to attend the training session, send a prompt acknowledgment informing them when final confirmation and further details will be sent. Set a cut-off date, at which point you decide if there are enough bookings to make a viable session.

Once you have enough people booked, contact them again with brief details and suggested prior reading. Although not essential, by suggesting some prior reading you are indicating that this is in depth CPD which requires some commitment on the part of the attendees. It also gives you a chance to establish some dialogue with attendees prior to the event. With a week to go, you could mail a reminder and enquire about the reading and whether it would be useful for teaching. This helps keep the attendees focused on the event.

Prior Reading and Preparation

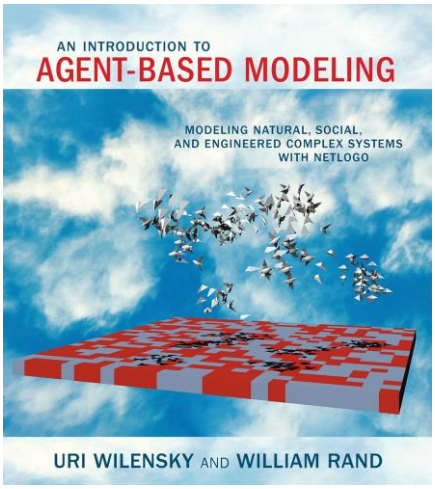
It is likely that most attendees have little prior exposure to the ideas covered in this session. An introduction to the concept of emergent behaviour would be valuable preparation. There are plenty of pointers to this – emergence has become a 'hot' topic in science recently. An excellent starting point would be for attendees to explore the TED Ed lesson at goo.gl/SsFnBo. Whilst they may have limited time to explore beyond the initial lesson, the 6 minute introductory video is very good preparation for this session.

The scientific importance of emergent behaviour is well summarised in a 12 minute video, taken from the popular American channel NOVA Science Now. First aired in 2012, it is worth watching, despite the low resolution: youtu.be/Nu7Zcj8HGUk. It makes explicit the interconnected nature of many of the ideas we will touch on and is particularly pertinent as an introduction to Artificial Intelligence. The full documentary (25 mins) is currently available at youtu.be/qPP9XemRzkA. This is flagged up at the end of the session, but watching beforehand would again make ideal preparation.

Further Reading

Most of the ideas for these activities came from two wonderful sources.

Firstly, Project GUTS: Growing Up Thinking Scientifically. Based at the Santa Fe Institute, they have provided a lot of material for exploring modelling in science. As well as material shared with Code.org using StarLogo Nova (https://goo.gl/KzmoqC), they have organised two MOOCs to introduce the ideas of modelling Complex Adaptive Systems. One is based on StarLogo TNG, the other Nova. A further MOOC introduced NetLogo. All the material has been excellent. More details of their activities and how to register can be found on their website: http://projectguts.org



Other exercises were based on materials produced by the Scheller Teacher Education Partnership (Step) at MIT. There are lots of excellent supplementary materials hosted here - this link is well worth exploring: goo.gl/5lFOUg.

We shared a paper by Resnick and Wilensky in the session. Please take the time to read it for suggestions of further kinaesthetic activities to reinforce the concepts involved in agent based modelling.

Finally the documentation included with the each of the sample programs in NetLogo is a very good place to start if you wish to take these ideas further. Wilensky and Rand have recently published a very thorough book which provides a carefully structured introduction to agent based modelling which references many of the NetLogo programs.

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Well before the session is due to take place ensure you have considered computer access. Check whether attendees will be logging on to institution machines or bringing their own laptops. If BYOD, ensure that is made clear in any prior publicity. Check that the venue has a projector and speakers.

Three pieces of software need installing and testing beforehand: Bridge Designer 2016 (available from goo.gl/ynY0UF), StartLogoTNG (goo.gl/xYcsgF) and NetLogo (goo.gl/gbJlnC). All are free.

Ensure there is enough space for the kinaesthetic activites. Some of these are best outdoors, but all can be done in the classroom if required.

Ensure you have the following general material:

- Facilities for taking notes (paper and pens)
- A3 Computational Thinking Posters
- CAS Publicity: Copies of SwitchedON, BCS Certificate flyers and any local information

Attendee / Trainers Materials and Resources

Attendee materials are in black, requiring one copy per person. Supplementary trainer's materials for demonstration purposes are indicated in red (single copy only required). Continues overleaf.

Activity	Materials (Per Attendee)	
Analytical Models	Bridge Design 2016 software installed	☐
	Teachers Notes	☐
Decentralised Systems	StarLogoTNG installed	☐
	Hungry Turtles programs	☐
	African Plains program	☐
	Complex Model Investigation: African Plains sheet	☐
	Project GUTS African Plains video	☐
	Project GUTS Blind Mice video	☐
	Teachers Notes	☐
Emergent Behaviour	Termite Grid, blocks, dice, coins	☐
	Termite instructions and commands	☐
	Termite programs	☐
	Complex Model Investigation: Termite sheet	☐
	Resnick / Wilensky paper: Diving Into Complexity	☐
	Teachers Notes	☐
Complex Investigations	Epidemic programs	☐
	NetLogo installed	☐
	Wolf Sheep Predation resources	☐
	Teachers Notes	☐

Building Models	Paper Catchers instructions and newspapers Undersea World programs Building A Marine Eco-system activity & more challenging version Teachers Notes	☐ ☐ ☐ ☐
Reflective Practitioner	BCS Certificate Flyers Trainers Notes	☐ ☐

The presentation included in the unit is designed to support a full one day session, delivered to CAS Master Teachers and other curriculum champions. It will likely be fast paced, delivered to experienced teachers.

It is envisaged that those attendees will take the material and deliver shorter sessions, either as half day, twilight or CAS Hub inputs. It is expected these will take longer to cover each activity as the material will be unfamiliar to teachers new to Computer Science. Please find time to discuss with attendees possible ways to use the material and encourage them to offer further sessions in their locality.

Resources

All supporting material is available for download, corresponding to each session in the Unit.

The material includes

- a full presentation to support all the activities covered in the Unit
- a set of Teachers Notes explaining the material for each session
- separate activity handouts and electronic resources

If you intend to use the material at shorter sessions, simply hide the slides in the presentation not used.

If you wish to combine material in a different order please consider adding slides to introduce the 'big picture' at the start and to discuss being a reflective practitioner at the end. That said, this presentation is slightly different to most Tenderfoot units in that it is almost wholly oriented on a particular programming environment. As such, each session builds on that which went before.

If you do decide to cover the material in a different order, please consider whether the groundwork has been adequately covered to tackle the particular tasks you choose. Try also to stick to the CAS House Style should you add or amend slides, which is outlined on the opening introductory slide notes.

Half Day / Twilight CPD Sessions

It is suggested the material could be delivered as 5 separate shorter sessions, as indicate by the sessions.

- **Analytical Models:** This stands alone and serves as an introduction to analysing bridge design models.
- **Decentralised Systems:** A lengthy session that could be split in two. Introduces StarLogoTNG and the key ideas behind decentralised systems and agent based modelling.
- **Emergent Behaviour:** A logical follow on from the last session. To stand alone, it would likely require some of the introductory material from Decentralised Systems.
- **Complex Investigations:** Requires some foundation and knowledge of StarLogoTNG first, but could stand alone as a separate session.
- **Building Models:** A largely practical session that could easily follow Decentralised Systems.

Of course, Master Teachers and other trainers can combine sessions and activities as they feel best fit the local circumstances. Any CPD session should be topped and tailed with the Introduction and Conclusion slides as the exemplar (left) demonstrates. Do please consider including 'pauses for thought' and provide an opportunity to publicise the BCS Certificate.

Many activities are short enough to introduce at CAS Hubs or worked through in a school departmental meeting. Whatever ways you choose, the aim is to develop teacher appreciation of CS concepts, not just demonstrate an activity. We hope they are useful.