Biology students building computer simulations using StarLogo TNG, a graphical programming environment

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Effective Learning in the Biosciences, 1 July 2011

The Context

- Senior Honours module **“Complex Systems in Animal Behaviour”**

- Biology Senior Honours modules
  - Small group teaching (8-12 students)
  - Specialised topics (often research-related)

Complex Systems

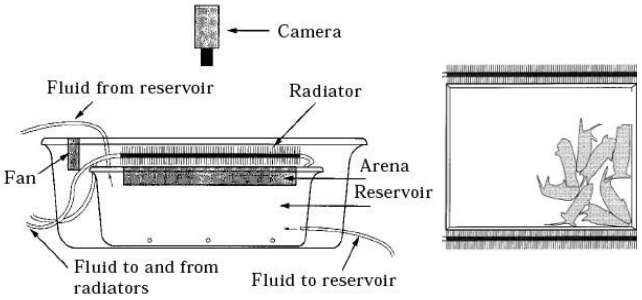
- Interdisciplinary subject
  - biology intersects with mathematics, physics, computer science

- Key concepts
  - self-organisation
  - emergence

Sumpter 2006, Phil Trans R Soc Lond B 36:5-22

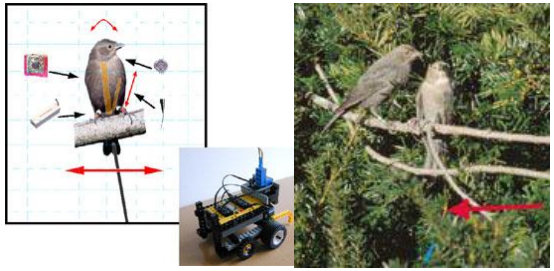
Studying Complex Systems

- detailed observation, mathematical modelling, **computer simulation**, robots



Schank & Alberts 1997, J Theor Bio.189:11-25

Reynolds 1987, Computer Graphics 21:25-34



http://www.indiana.edu/~aviary/Newtechniques.htm

Tong 2002 Tech Rep CMU-RI-TR-02-29 Carnegie Mellon

Computer Practical

- Wanted to enable students to experience building a computer simulation

- But…
  - most SH Biology students not conversant with programming

StarLogo TNG

- Developed by MIT’s Education Labs
- Graphical programming interface
- Agent-based modelling
- Available free for Windows & Mac & Linux

The Practical

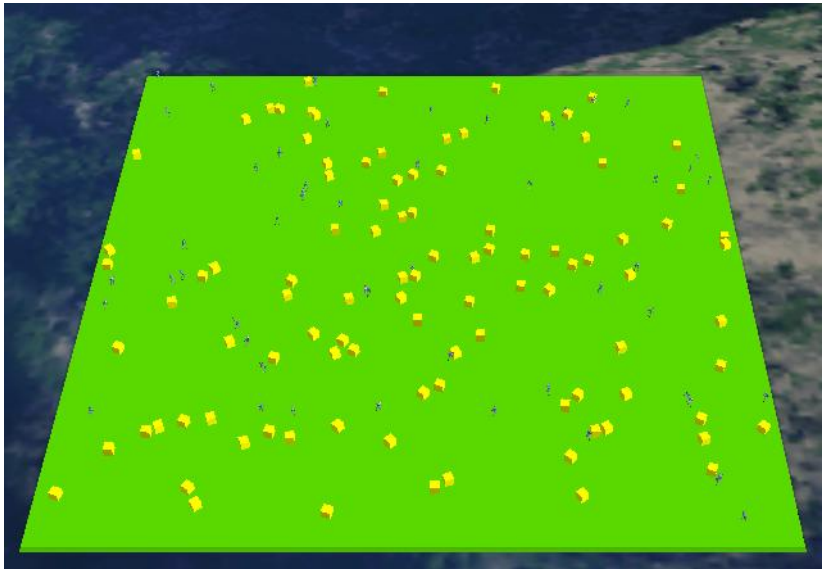
- Two 2-hour sessions
- First session
  - learning to build simulation
- Second session
  - modify simulation on own

Ants & Granules

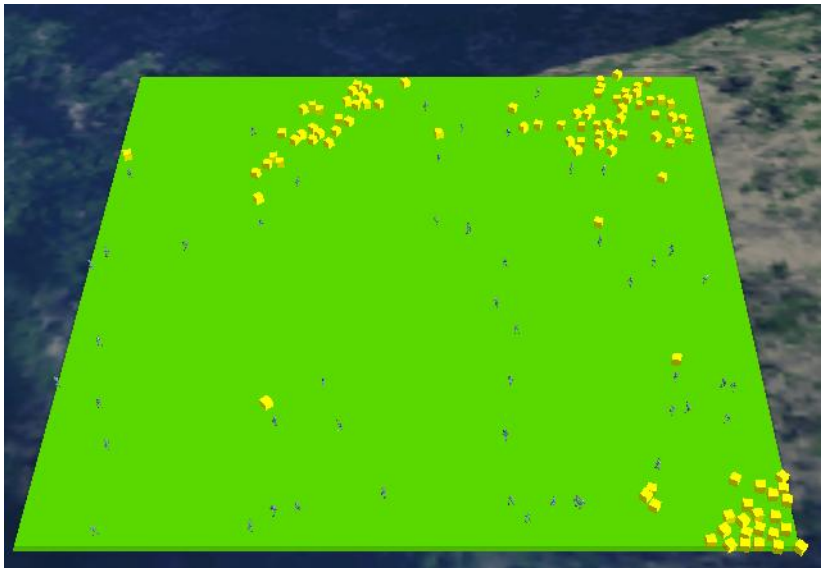
- Based on ants building nests *(Franks et al 1992, An Beh 44:357-375)*
- Simplified rules
  - ants wander until they encounter granule and pick it up
  - ants wander until they encounter another granule and drop the one they are carrying

test
Turtles
food?
then
left
degs
90
forward
steps
1
set energy
1
ward
steps
1
nergy
-1
StarLogo TNG:
The Next Generation
Version 1.0, Copyright 2008

Emergent Property



initial random distribution



granules in clumps

Learning

- Step-by-step instructions to build simulation from scratch
  - follow **process** of programming, not just putting pieces together
- Process
  - constantly checking results
  - debugging for desired output

The dip in the top of the *create Ants* command fits into the overhand in *setup*. *create Ants* has another bump on its underside, which will allow more commands to be added.

- Move *create Ants* over to *setup*, connecting the bump and dip. It clicks into place, and the *setup* slot expands a little to allow it to fit.
- We'd like more than 10 Ants, so click on the number *10* and change it to *50*.

Now we'll do the same thing for Granules.

- Clicking on the button *Granules* opens a drawer from which you can choose *create Granules (num)*.
- Click this into *setup* below *create Ants*.
- Change the number from *10* to *100*.

B. Let's see what we've done so far. Go to the SpaceLand window. Click on *setup*. What happens now?

We've made 50 Ants and 100 Granules, but they are all standing on top of each other in the centre of the land. We'd rather have them scattered throughout. Go back to StarLogoBlocks.

- Return to the Factory (click on arrow to left of My Blocks, labelled "Factory").
- Click on *Setup and Run* and choose from the drawer the command *scatter everyone*.
- Click this in below *create Granules*.

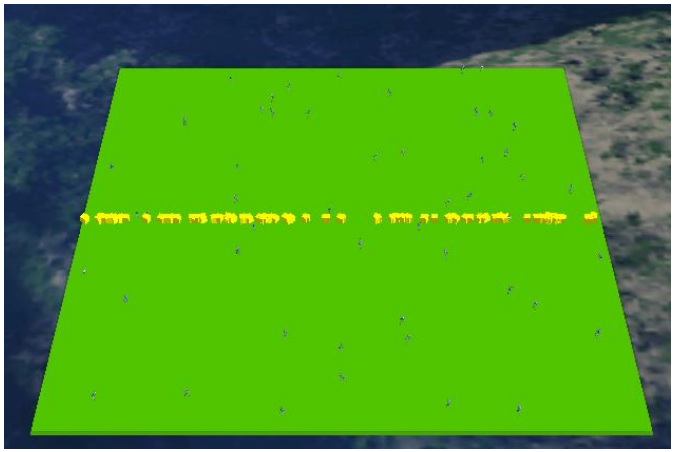
C. Go to SpaceLand and click on *setup*. Now what happens?

Modifying

- Provide completed version of simulation
- Ask students to modify characteristics and run a small simulation experiment

Student Modifications

- Change angle of turn
- Change height of granules
- Change numbers
- Change initial distribution
- Change shapes
- etc.



Survey Experiment

- Pre- and post-surveys
- Ask
  - perceptions of computer programming
  - MCQ questions requiring understanding code

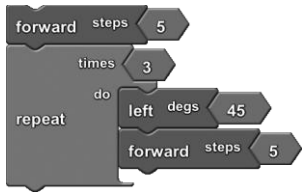
value-based

```
int a = 10;
a = a + 1;

The new value of a is:
```

word-based

```
int a = 10;
if (a < 20) then
   {print “hello ”;}
else
   {print “bye ”;}

The printout would read:
```

StarLogo-based



The path of an agent following these instructions would look like:

  - confidence on answers

with Dr Ishbel Duncan, Computer Science

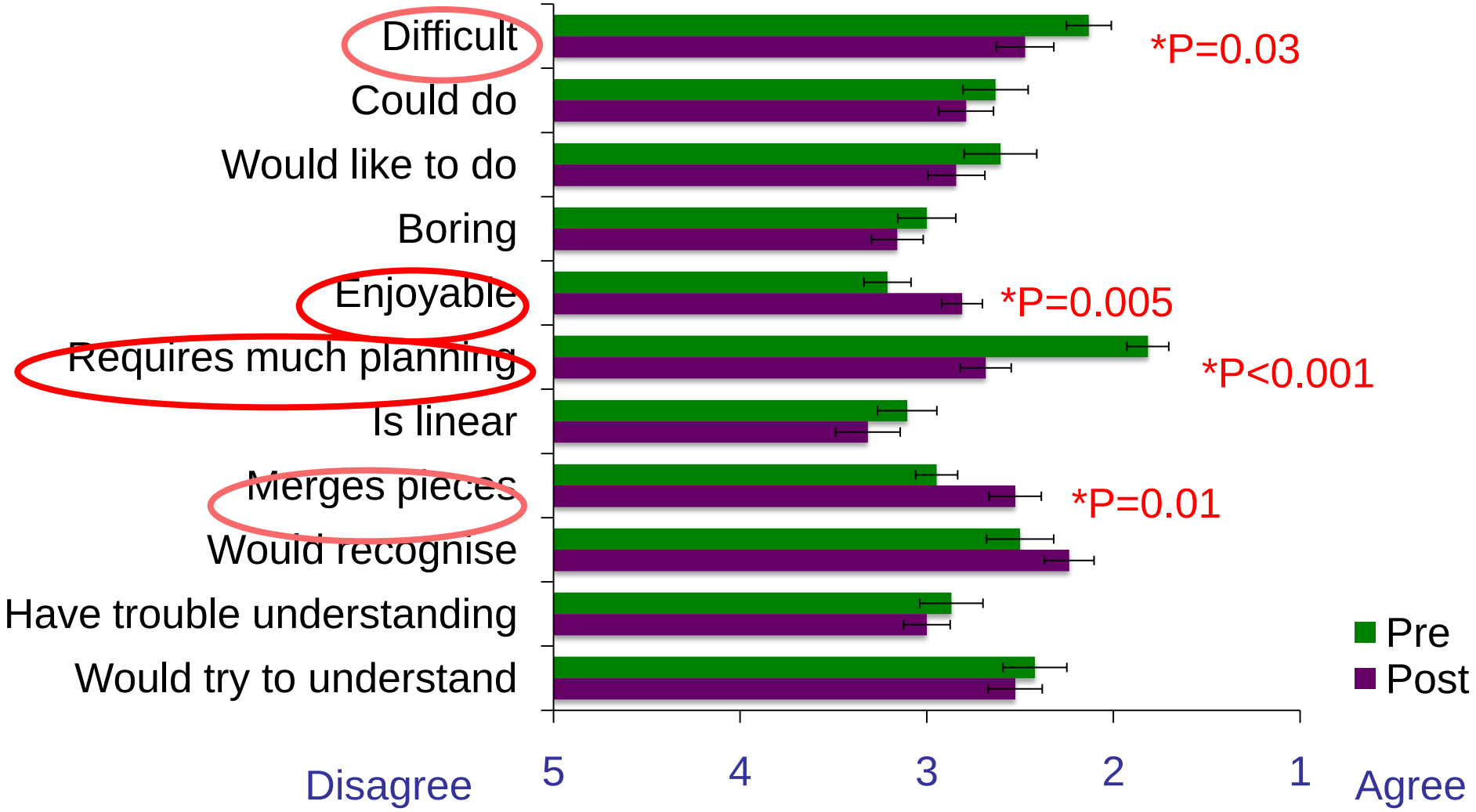
Survey Experiment

- Preliminary results
  - 15 students from St Andrews in 2010 + 2011
  - 23 from Anglia Ruskin in 2011 (thanks to Dr Toby Carter!)
- Continuing experiment
  - *contact me (anne.smith@st-andrews.ac.uk) if you might use StarLogo & could give surveys*

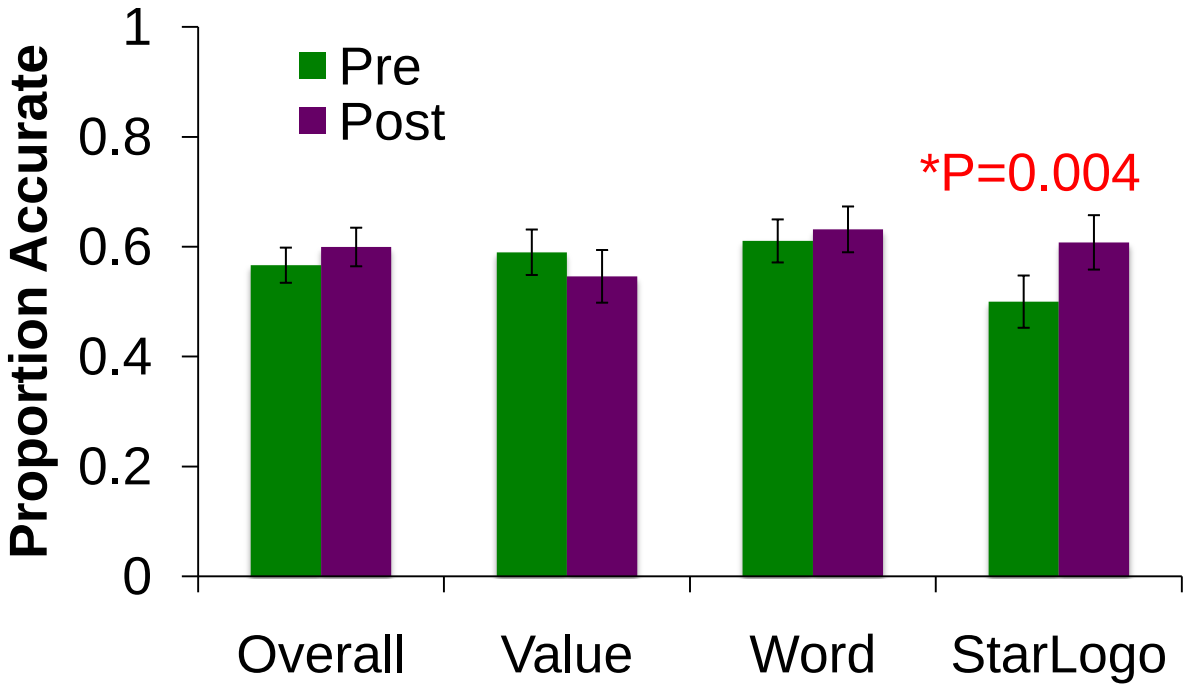
with Dr Ishbel Duncan, Computer Science

Perceptions

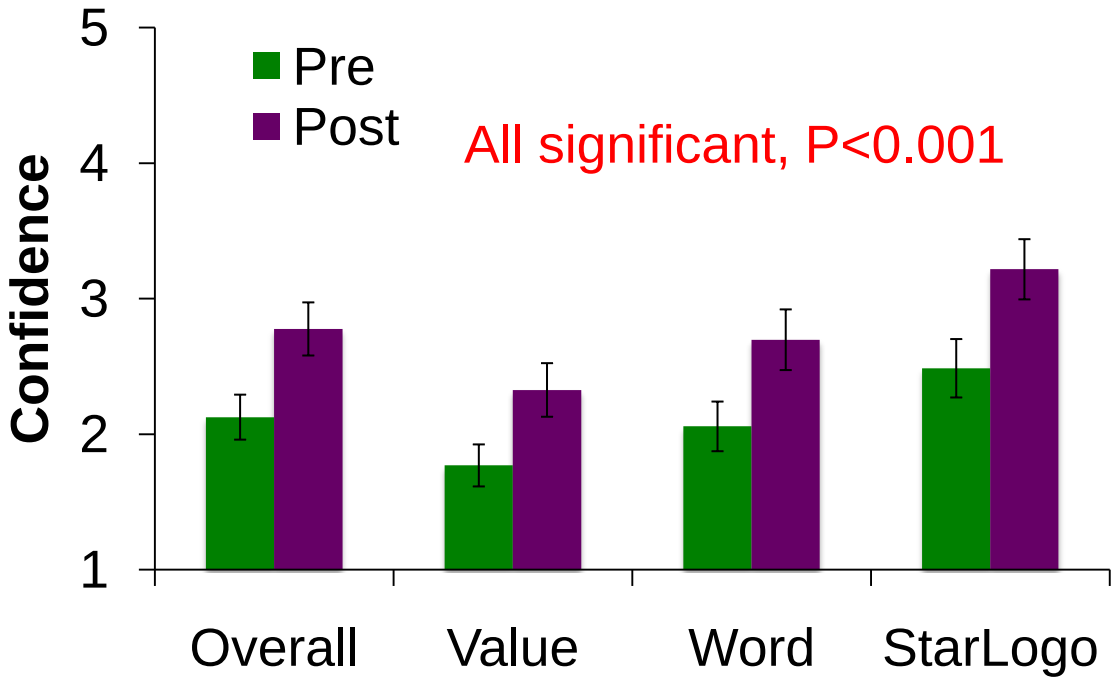
Uncorrected paired t-test



Questions - Accuracy



Questions - Confidence



Summary

- Students enjoy StarLogo
- Students learn about programming
- Perceptions
  - less difficult, more merging pieces (?)
  - more enjoyable, requires less planning (stronger evidence)
- Understanding code
  - accuracy increases on StarLogo-based
  - confidence increases overall

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