"The convergence of 'open work' leading to the prospect of every child in every country programming their own notebook computer?”

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4 Educational Technology Projects

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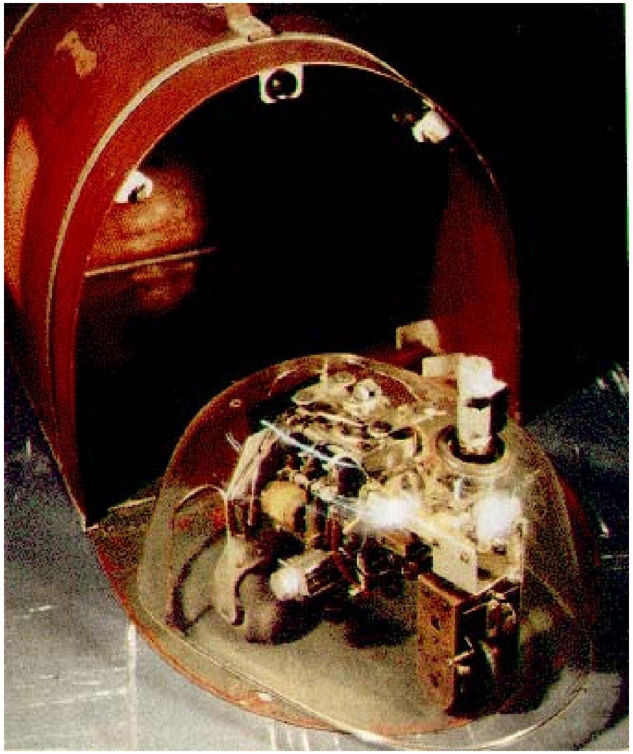
発表の概要

- Early programming projects =>
- Recent programming activities
- Notebook computers for every child =>
- A ‘green machine’ for every child

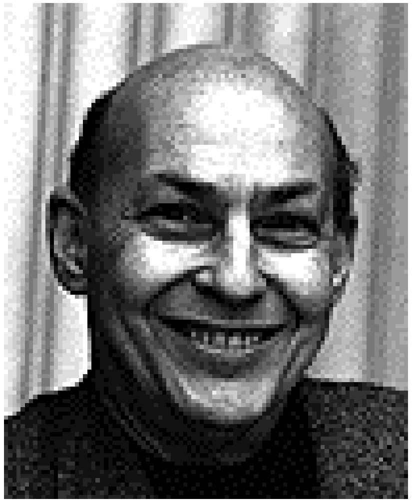
Early programming projects

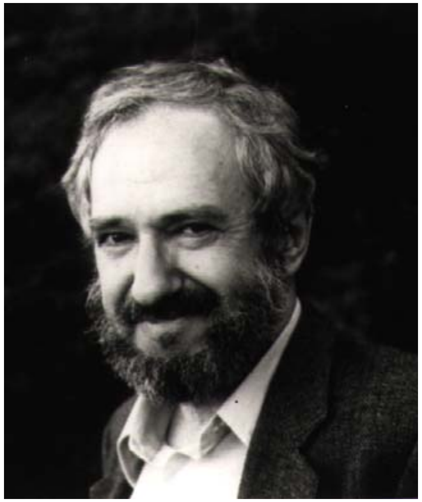
- Dr Grey Walter - neurophysiologist investigating mobile autonomous robots in 1940’s
- Made the first ‘turtle’



At MIT in the 1970’s…

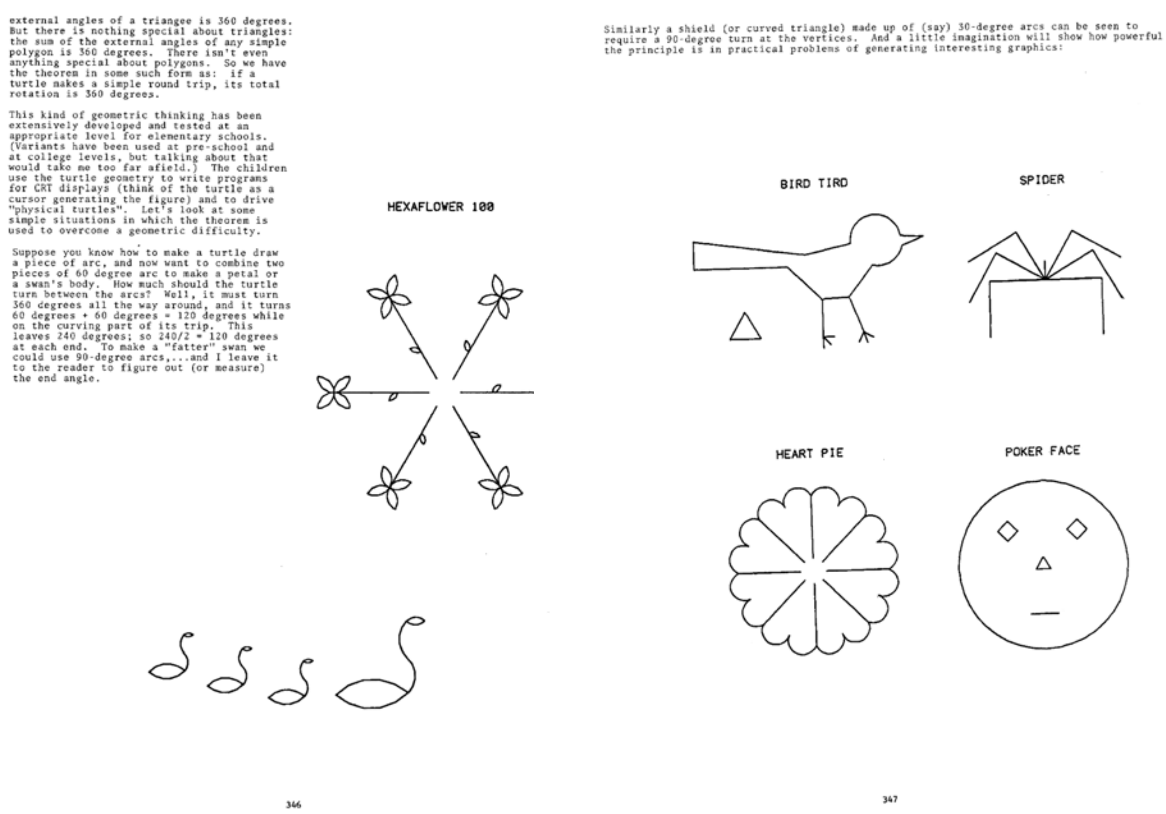
- Marvin Minsky and Seymour Papert were working with LISP and founded the MIT Artificial Intelligence Laboratory.
- They built a ‘turtle’ for children to play with in their research into artificial intelligence and children.





In 1972, Seymour wrote about..

- Theorem
  make se
  were ‘rea



external angles of a triangee is 360 degrees. But there is nothing special about triangles: the sum of the external angles of any simple polygon is 360 degrees. There isn't even anything special about polygons. So we have the theorem in some such form as: if a turtle makes a simple round trip, its total rotation is 360 degrees.

This kind of geometric thinking has been extensively developed and tested at an appropriate level for elementary schools. (Variants have been used at pre-school and at college levels, but talking about that would take me too far afield.) The children use the turtle geometry to write programs for CRT displays (think of the turtle as a cursor generating the figure) and to drive "physical turtles". Let's look at some simple situations in which the theorem is used to overcome a geometric difficulty.

Suppose you know how to make a turtle draw a piece of arc, and now want to combine two pieces of 60 degree arc to make a petal or a swan's body. How much should the turtle turn between the arcs? Well, it must turn 360 degrees all the way around, and it turns 60 degrees + 60 degrees = 120 degrees while on the curving part of its trip. This leaves 240 degrees; so 240/2 = 120 degrees at each end. To make a "fatter" swan we could use 90-degree arcs,...and I leave it to the reader to figure out (or measure) the end angle.

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Similarly a shield (or curved triangle) made up of (say) 30-degree arcs can be seen to require a 90-degree turn at the vertices. And a little imagination will show how powerful the principle is in practical problems of generating interesting graphics:

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Proceedings of the ACM Conference, 1972.

And…

- “Teaching Children to Be Mathematicians vs. Teaching About Mathematics”

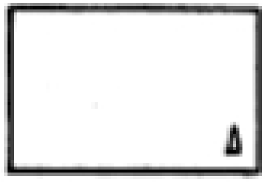
1. Preface

Being a mathematician is no more definable as "knowing" a set of mathematical facts than being a poet is definable as knowing a set of linguistic facts. Some modern math ed reformers will give this statement a too easy assent with the comment: "Yes, they must understand, not merely know." But this misses the capital point that being a mathematician, again like being a poet, or a composer or an engineer, means doing, rather than knowing or understanding. This essay is an attempt to explore some ways in which one might be able to put children in a better position to do mathematics rather than merely to learn about it.

(1971) Publication no. 249 of MIT AI Laboratory;
International Journal of Mathematics Education and Science Technology, 1972.

At any time the turtle is at a particular place and facing in a particular direction. The place and direction together are the turtle's geometric state. The picture shows the turtle in a field, used here only to give the reader a frame of reference:

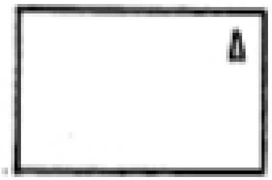
(1)



The triangular picture shows the direction.

FORWARD 50

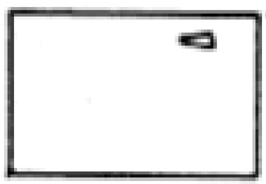
(2)



The turtle advanced 50 units in the direction it was facing.

LEFT 90

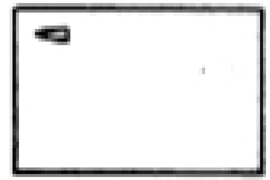
(3)



The turtle's position remained fixed. It rotated 90° to the left. So its direction changed.

FORWARD 150

(4)



The turtle advanced 150 units in its new direction.

LEFT 135

(5)

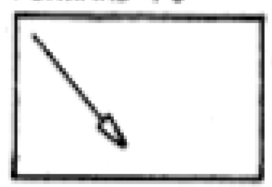
The turtle rotated left 135°.

PENDOWN

(Produces no visible effect. But the next FORWARD instruction will leave a trace.)

FORWARD 70

(6)



The effect of PENDOWN is to put the turtle in a state to leave a trace: the pen draws on the ground.

(1971) Publication no. 249 of MIT AI Laboratory;
International Journal of Mathematics Education and Science Technology, 1972.

3. Creativity? Mathematics?

In classes run by members of the M.I.T. Artificial Intelligence Laboratory we have taught this kind of geometry to fifth graders, some of whom were in the lowest categories of performance in "mathematics". Their attitude towards mathematics as normally taught was well expressed by a fifth grade girl who said firmly, "There ain't nothing fun in math!" She did not classify working with the computer as math, and we saw no reason to disabuse her. There will be time for her to discover that what she is learning to do in an exciting and personal way will elucidate those strange rituals she meets in the math class.

Typical activities in early stages of work with children of this age is exploring the behavior of the procedure POLY by giving it different inputs. There is inevitable challenge -- and competition -- in producing beautiful or spectacular, or just different effects. One gets ahead in the game by discovering a new phenomenon and by finding out what classes of angles will produce it.

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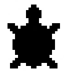
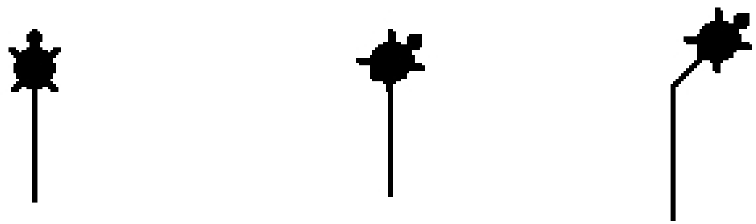
International Journal of Mathematics Education and Science Technology, 1972.

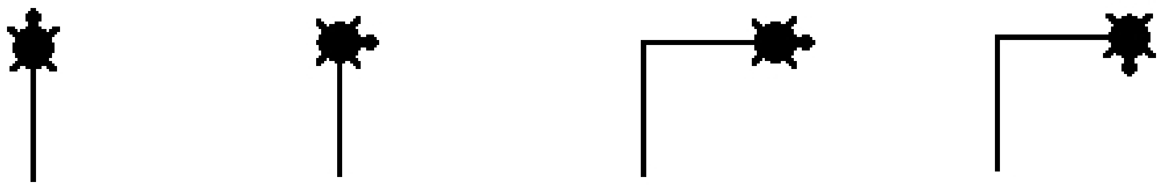


The screen turtle also understands **forward** and **right**.

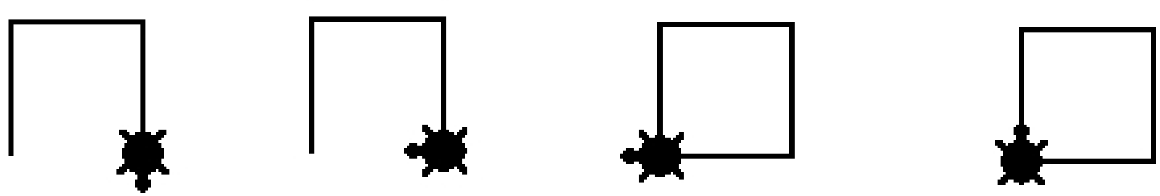


`forward 50`   `right 45`   `forward 25`

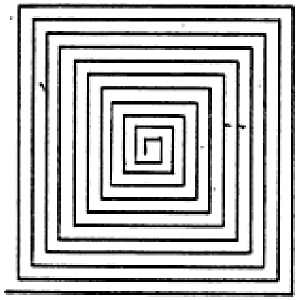
Following some exploratory messing around, a common first Turtle activity is to draw a *geometric* shape. How about a square?

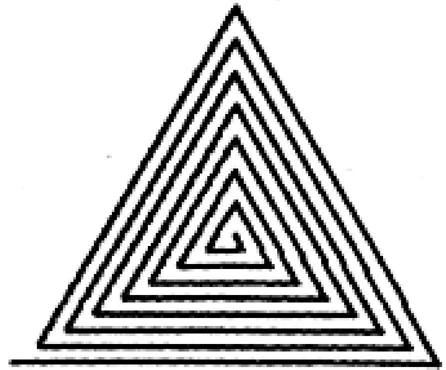


`forward 50`   `right 90`   `forward 50`   `right 90`

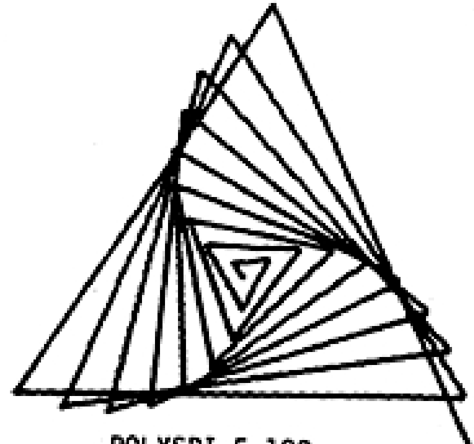


`forward 50`   `right 90`   `forward 50`   `right 90`





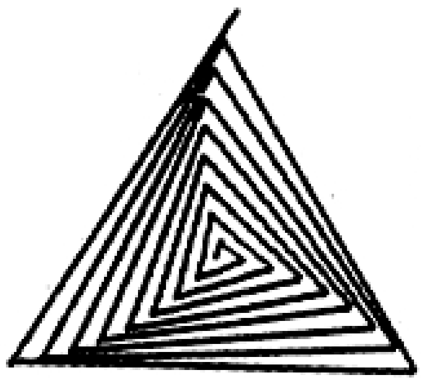
POLYSPI 5 120



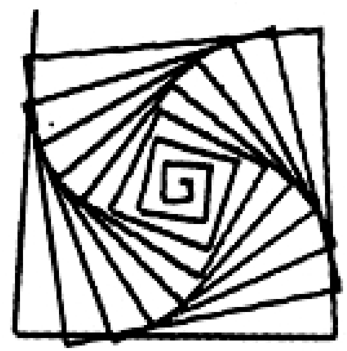
POLYSPI 5 123

What else produces similar effects?

Figure 8



POLYSPI 5 121



POLYSPI 5 93

The real excitement comes when one becomes courageous enough to change the procedure itself. For example making the change to POLYSPI occurs to some children and, in our class, led to a great deal of excitement around the truly spontaneous discovery of the figure now called a squiral (Figure 5). (Note: By spontaneous I mean, amongst other things, to exclude the situation of the discovery teacher standing in front of the class soliciting pseudo-randomly generated suggestions. The squiral was found by a child sitting all alone at his computer terminal!) By no means all the children will take this step -- indeed once a few have done so it becomes derivative for the others. Nevertheless we might encourage them to explore inputs to POLYSPI. There is room here for the discovery of more phenomena. For example, taking :ANGLE as 120 produces a neat triangular spiral. But 123 produces a very different phenomena.

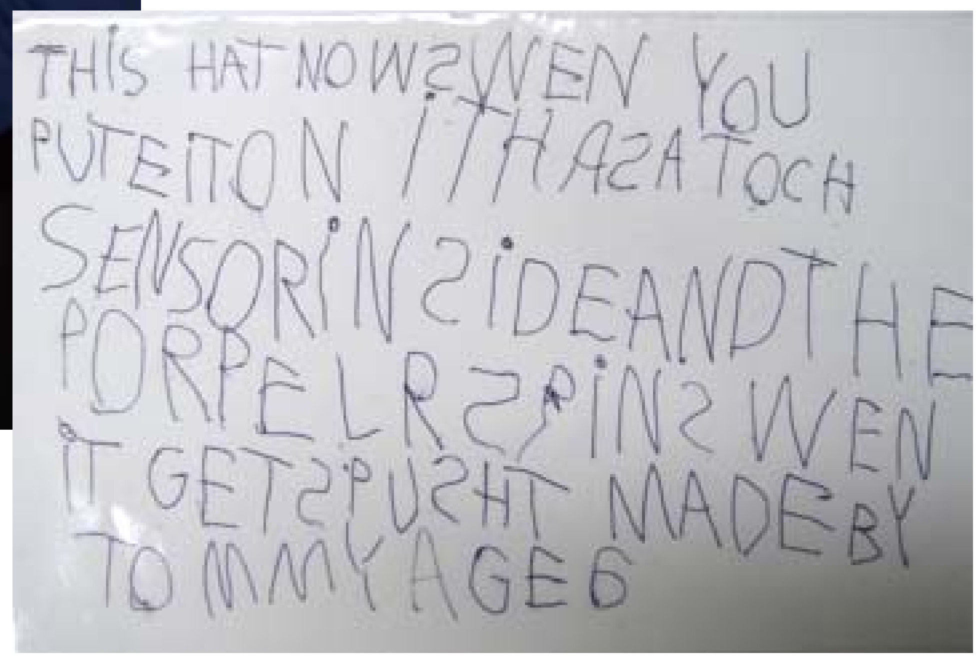
(1971) Publication no. 249 of MIT AI Laboratory;
International Journal of Mathematics Education and Science Technology, 1972.

So what happened…..

- Children in various places around the world played with turtles….

Screen turtles were taught …

- List processing - to make word processors, e.g. (with hot links!)
- Turtle geometry
- and an MBA student taught the turtle to manage a pottery business.
- LEGO bricks were also taught to do things…



From http://www.mit.edu/~sdh/invention_studio/12-02/photos.html

So kids were programming

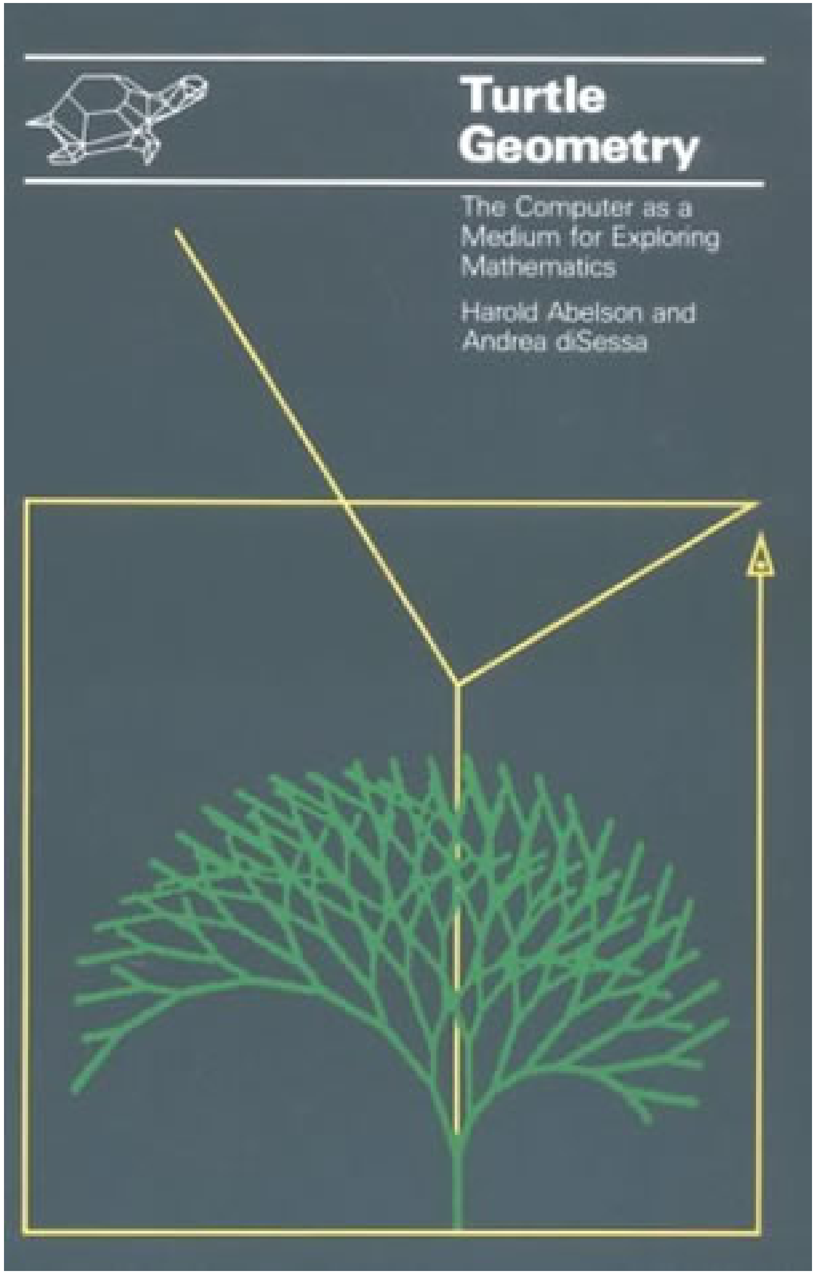
- things of interest to kids ….
- They were using a functional language to describe their commands…
- And programmes were built up by using pieces within pieces…

```
TO SQUARE :SIZE
REPEAT 4 [FD :SIZE RT 90]
END

TO SPINSQUARE :ANGLE :SIZE
REPEAT 36 [SQUARE :SIZE RT :ANGLE]
END

TO SPINTRIANGLE :ANGLE :SIZE
REPEAT …..
```

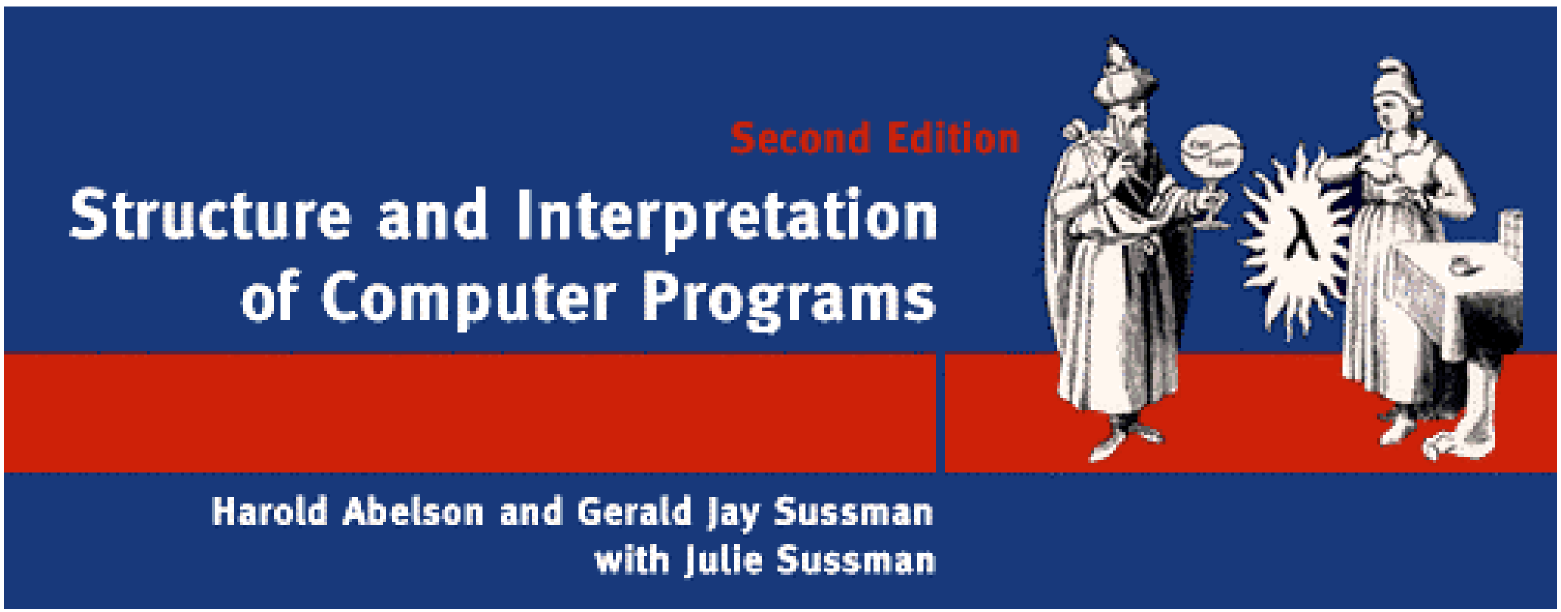
```
TO SQUARE
REPEAT 4 [FD 20 RT 90]
END

TO SQUARE :SIZE
REPEAT 4 [FD :SIZE RT 90]
END

TO POLY :SIDES :SIZE
REPEAT :SIDES [FD :SIZE RT 360/:SIDES]
END

TO POLYSPI :SIDES :SIZE :INC
FD :SIZE RT 360/:SIDES
POLYSPI :SIDES :SIZE :INC + 2
END
```

Meanwhile ….

- Andy di Sessa and Hal Abelson, the original programmers for Logo, wrote “Turtle Mathematics”.



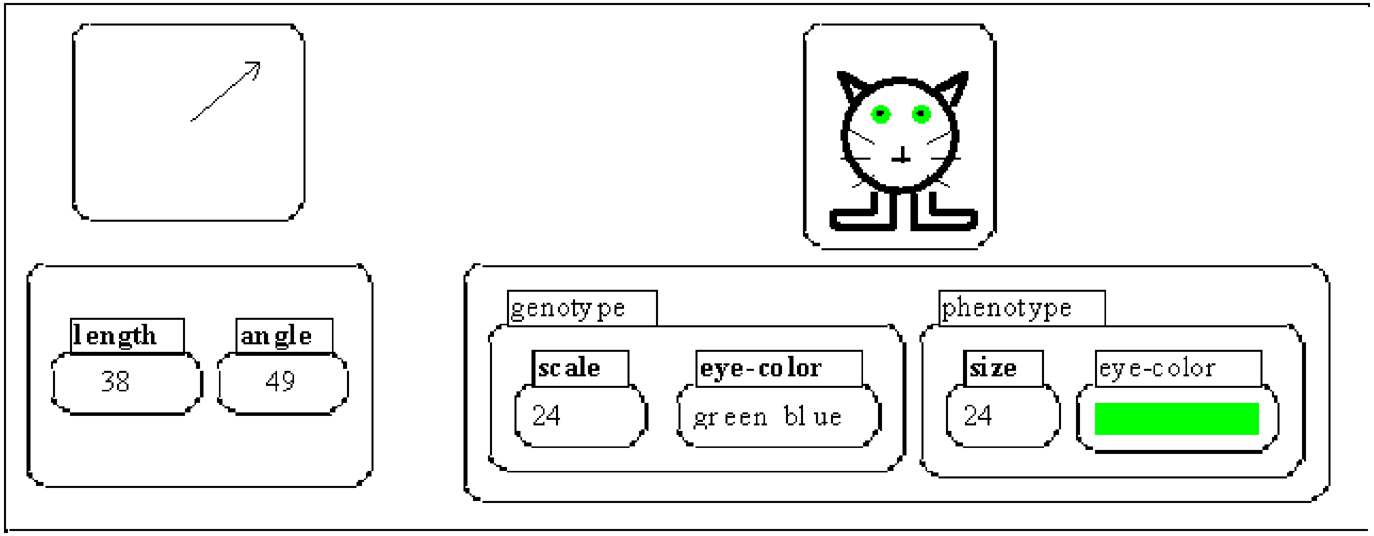
and Hal wrote



(Now Open Courseware from MIT.)

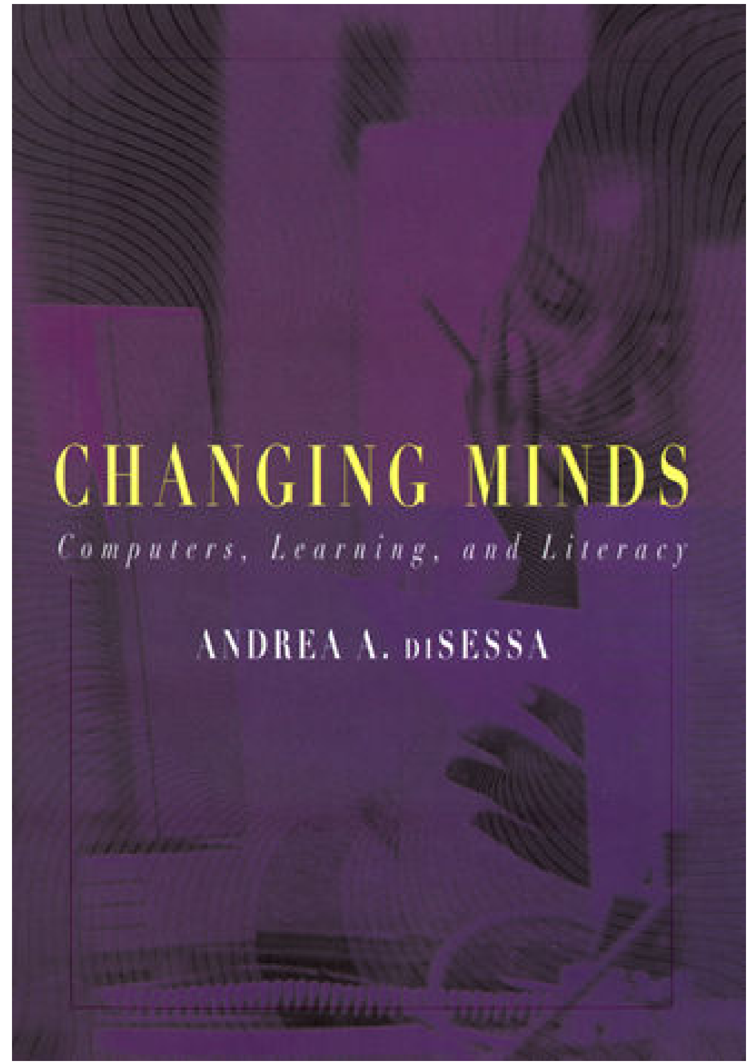
Meanwhile ….

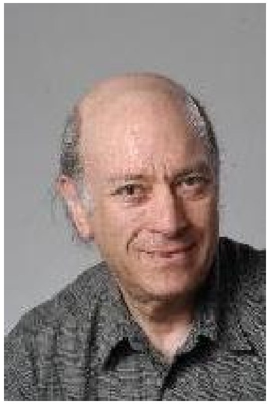
- Andy di Sessa and colleagues, now at Berkeley, developed Boxer.



and Andy wrote

- "Changing Minds Computers, Learning and Literacy" (2000)





Brian Harvey, at Berkeley,

developed Berkeley Logo

```
to choices :menu [:sofar []]
  if emptyp :menu [print :sofar stop]
  foreach first :menu [(choices butfirst :menu
                   sentence :sofar ?)]
end
```

And here's how you use it. You type

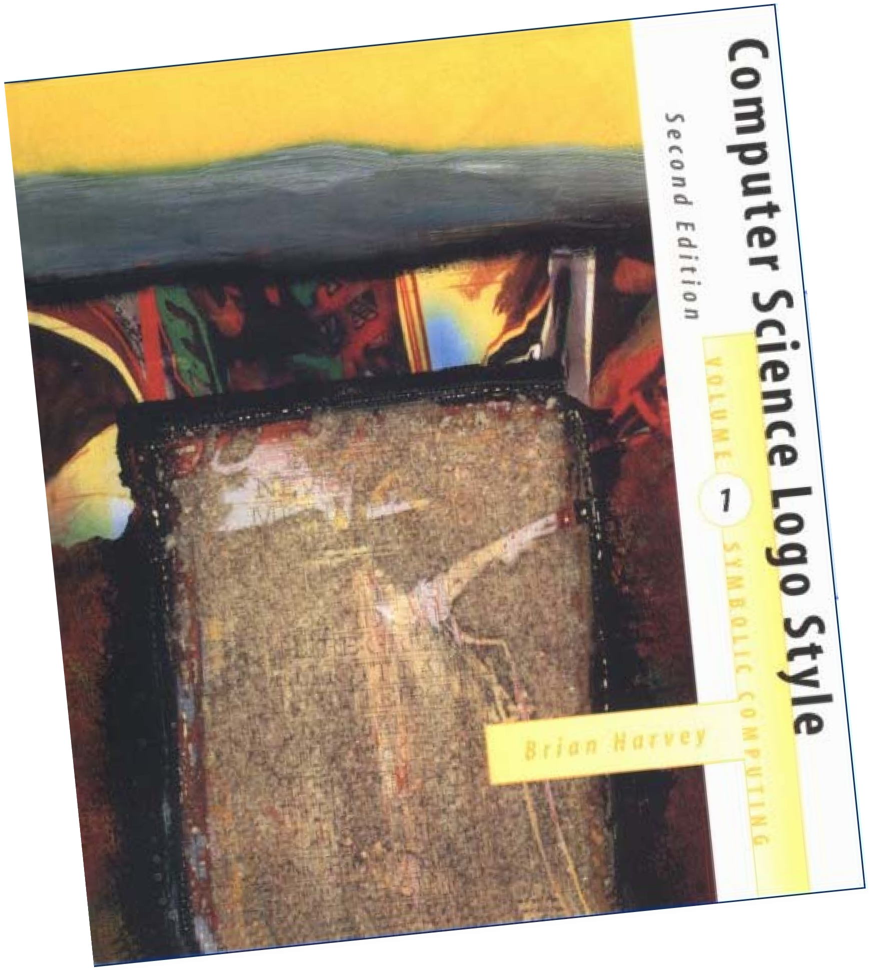
```
choices [[small medium large]
     [vanilla [ultra chocolate] lychee [rum
                     raisin] ginger]
     [cone cup]]
```

and Logo replies

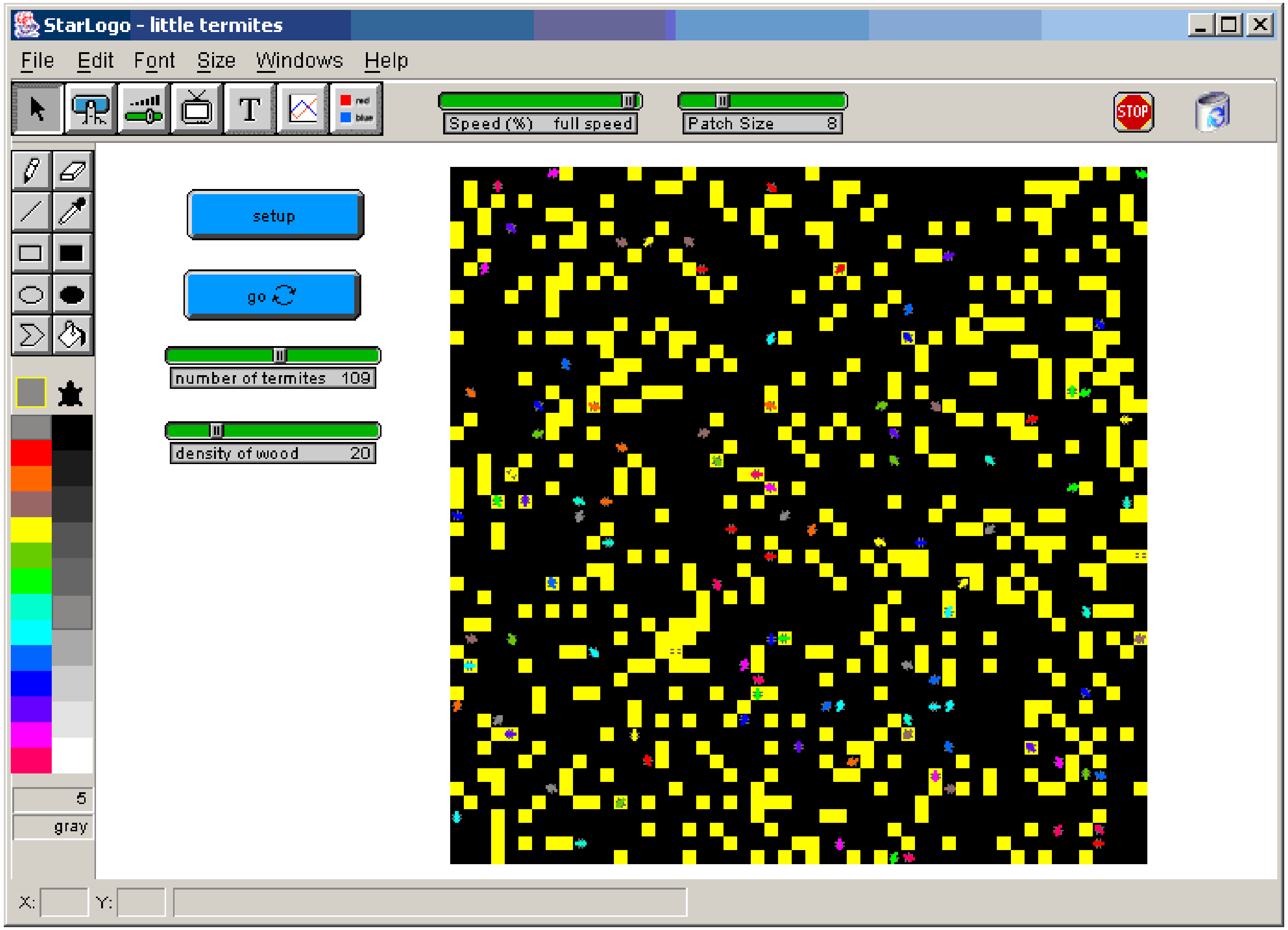
```
small vanilla cone
small vanilla cup
small ultra chocolate cone
small ultra chocolate cup
small lychee cone
small lychee cup
small rum raisin cone
small rum raisin cup
small ginger cone
small ginger cup
medium vanilla cone
medium vanilla cup
medium ultra chocolate cone
medium ultra chocolate cup
medium lychee cone
medium lychee cup
medium rum raisin cone
medium rum raisin cup
medium ginger cone
medium ginger cup
large vanilla cone
large vanilla cup
large ultra chocolate cone
large ultra chocolate cup
large lychee cone
large lychee cup
large rum raisin cone
large rum raisin cup
large ginger cone
large ginger cup
```

The program doesn't have anything about the size of the menu built in. You can use any number of categories, and any number of possibilities in each category. Let's see you do *that* in four lines of Java!

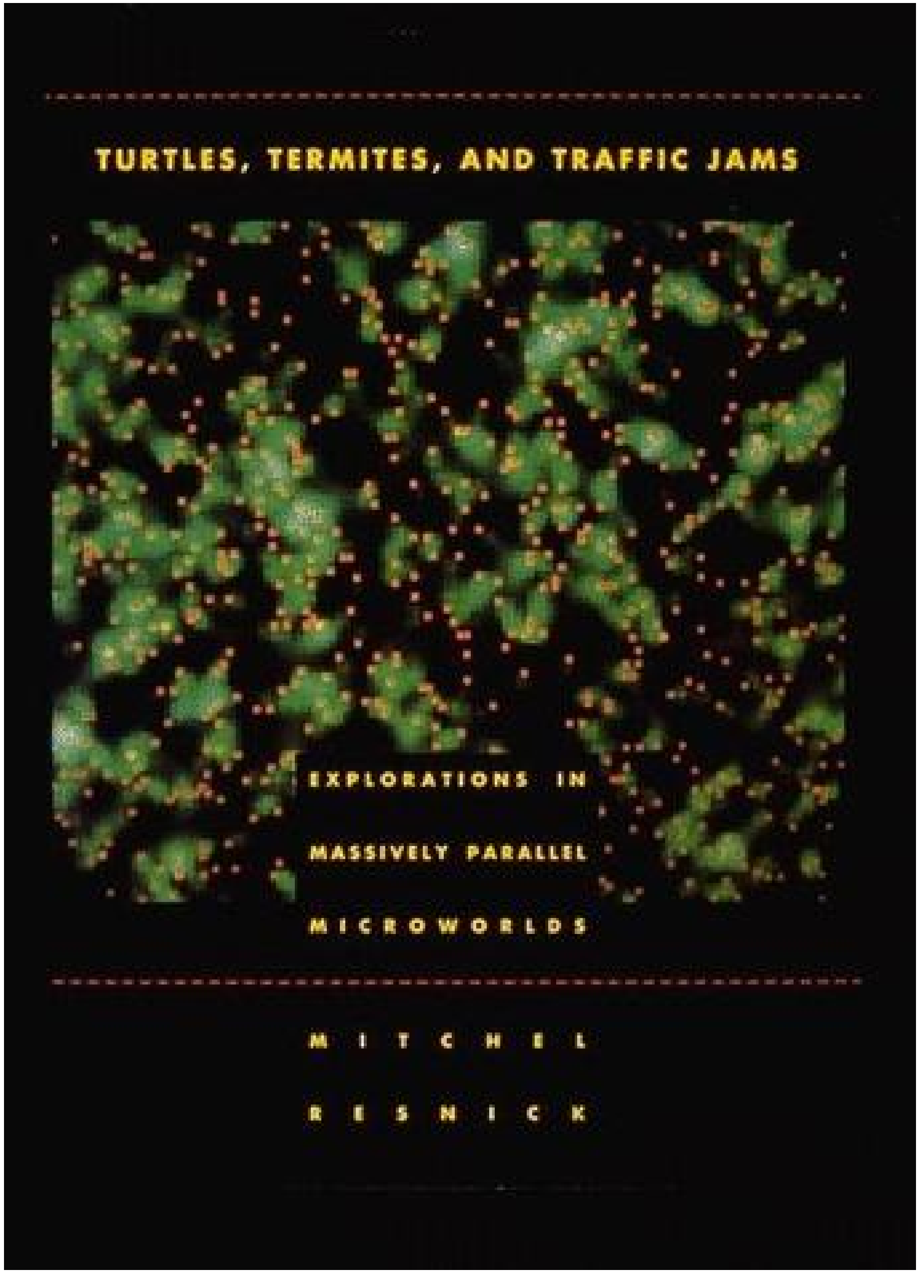
And Brian wrote (3 vols):



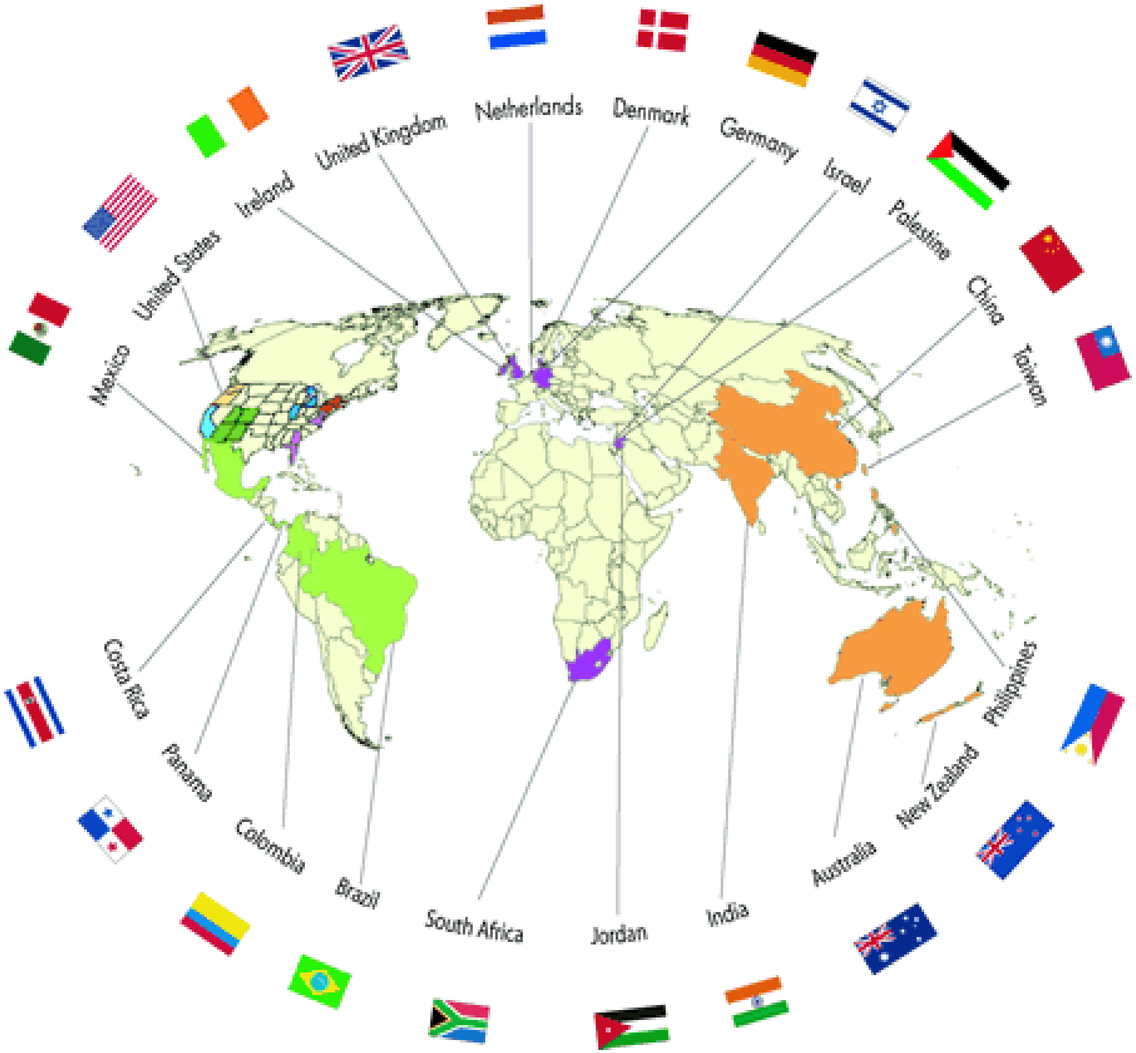
and Mitchel Resnick et al developed StarLogo



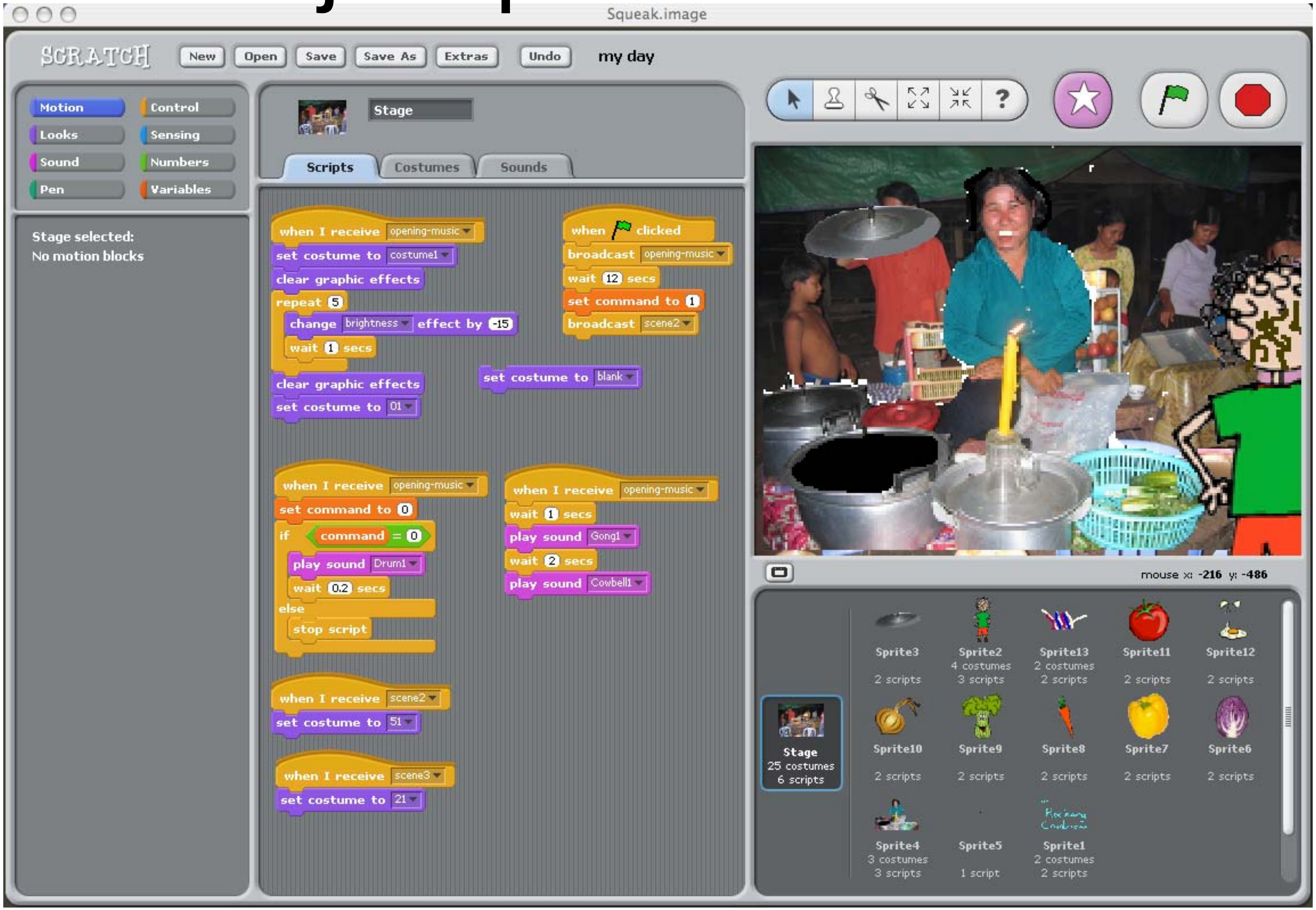
and Mitchel wrote:



and has set up 100 computer clubs



and has just produced Scratch



In fact,

- Millions of teachers and children have worked with these languages in hundreds of countries..
- And ‘artificial intelligence’ has helped kids learn in all sorts of ways in all sorts of disciplines.

AI and learning?

- Kids teach computers (the turtle) and so teach themselves and we and they see their thinking…
- Kids use intellectual prosthetics - word processing ‘writ large’
- Kids work in safe, artificial environments, eg every child playing with projectiles in the classroom ….
- But also

Artificiality to learn physics…

- Turtle geometry - [RT 90]
- Big Trak - RT 90

Notebook computers..

- 1986 - a notebook computer for every child in 2 Australian schools
  - A private girls school (parents bought computers)
  - A public mixed school (government bought computers)

All children learned programming.

Notebook computers..

We asked, “What would happen if …

- Computers were not only available when the teacher let them out ….
- If children were responsible for their computers …
- If children could learn at their own pace ..
- If teachers didn’t know more than the children…
- If children took control of the timetable …

Notebook computers..

In the event, we made sure that

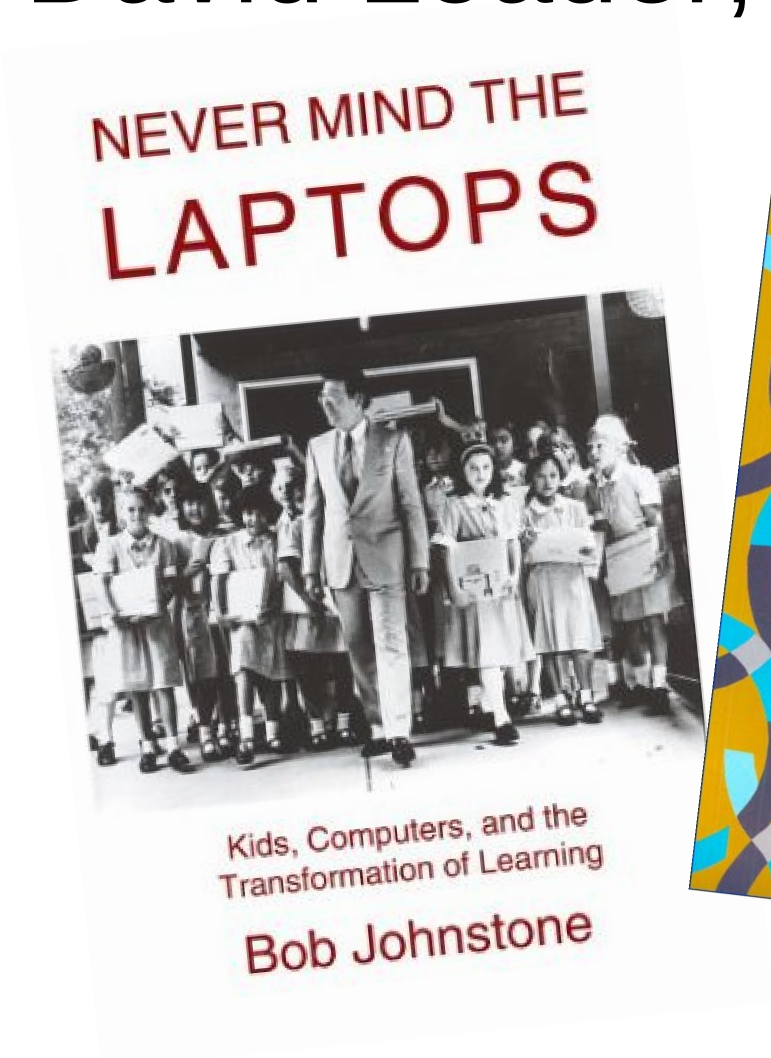
- Children were responsible for the computers
- Computer companies found themselves with a new type of customer
- Classroom practices, timetables and even the walls were flexible
- All children were to learn programming (all 12 years of schooling)
- Teachers were supported with personal experiences and training

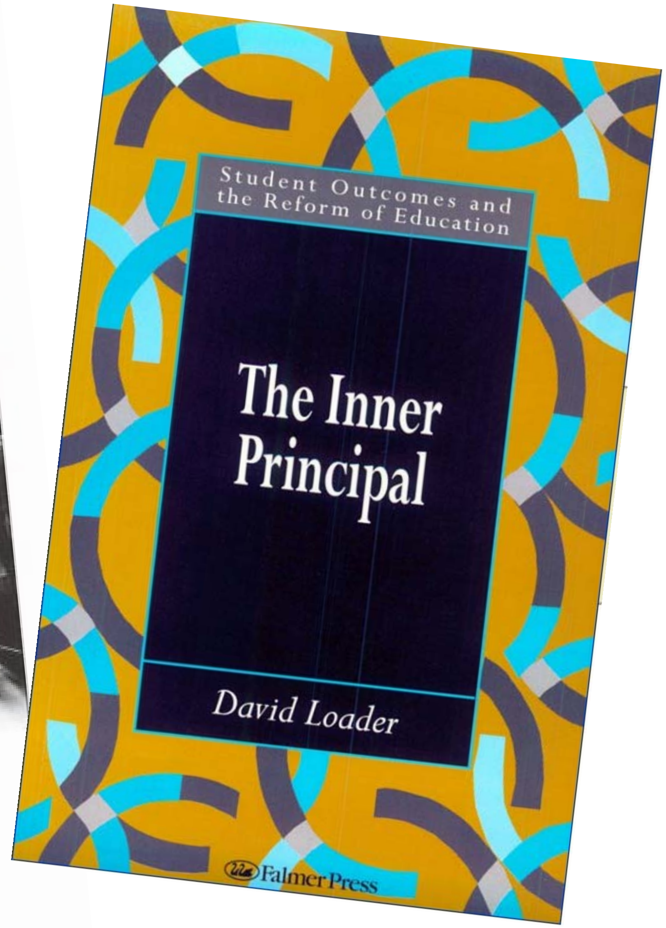
Notebook computers..

And we found that

- Children respected the computers and treated them very well
- Children and teachers changed the way they worked during school hours and what they did during school hours…
- Remarkable ‘intellectual’ things happened in the classrooms
- Many schools copied what they thought had been done…

David Loader, an amazing principal





"Learning with Personal Computers" - Helga Rowe

???? Michael Ryan…

Now,…

- Many many schools expect children to appear with notebook computers
- There is extensive literature about how to do it, what to expect, whether it makes a difference, how much it costs, …..
- Just a sample from one reference Web site…

QuickTime™ and a
Video decompressor
are needed to see this picture.

From http://www.eddept.wa.edu.au/cmis/eval/curriculum/ict/notebooks/

A United Nations Project …

- Nicholas Negroponte, former head of the Media Laboratory at MIT, is now working on a new project to make it possible for all children, everywhere, to have note book computers, especially children in third world countries where they do not otherwise have good learning facilities.

Is it possible?

- Special screens
- Special power-saving software, screens etc
- Special user software
- Special curricula? Special schools?
- The aim is to use the finances from orders of 1,000,000s of computers to finance their development.

Who’s helping?

- Five corporate sponsors, including Google and Advanced Micro Devices, have chipped in $2 million apiece to form a nonprofit group, One Laptop Per Child (OLPC), to oversee the project.
- Nearly a half-dozen developing countries, including the education ministries in Brazil and Thailand, have expressed interest in ordering 1 million or more units.
- The U.N. Development Program has agreed to help distribute the machines.

Does it make sense?

- A Japanese resident has arranged for 290 groups of charitable people to each contribute ¥1.5m to build a school in Cambodia.
- The schools are built but there are almost no trained teachers, no text-books, no adult English speakers.

Does it make sense?

- Kids work through school in shifts, some in the mornings and some in the afternoons.
- The schools are built but there are almost no trained teachers, no text-books, no adult English speakers.
- Communications are essential to the safety of the people.

In such a school, adding computers means a lot..

Currently,

- We are experimenting with children and the new programming language Scratch and some English teaching software and …
- We are hoping that we can use the computers in many different ways to bring many new facilities to the rural villages.

We have been trying out Scratch…

- Here in Tsukuba, and in Cambodia.
- Two precious stories come from this short experience:
- a boy in Reaksmy Village School and
- a girl in Tsukuba.

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

So,

- We do not think only children in 3rd world countries will benefit
- In the past, computers have been introduced into schools for what they can bring into the schools, but also, for what they do to schools.
- They can be thought of as an educational 'Trojan horse' ….


W. Friedrich: The wooden horse, c.1894. Photo ©Maicar Förlag-GML

From http://homepage.mac.com/cparada/GML/WOODENHORSE.html


ありがとうございます。