ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

CS-411 : Digital Education & Learning Analytics

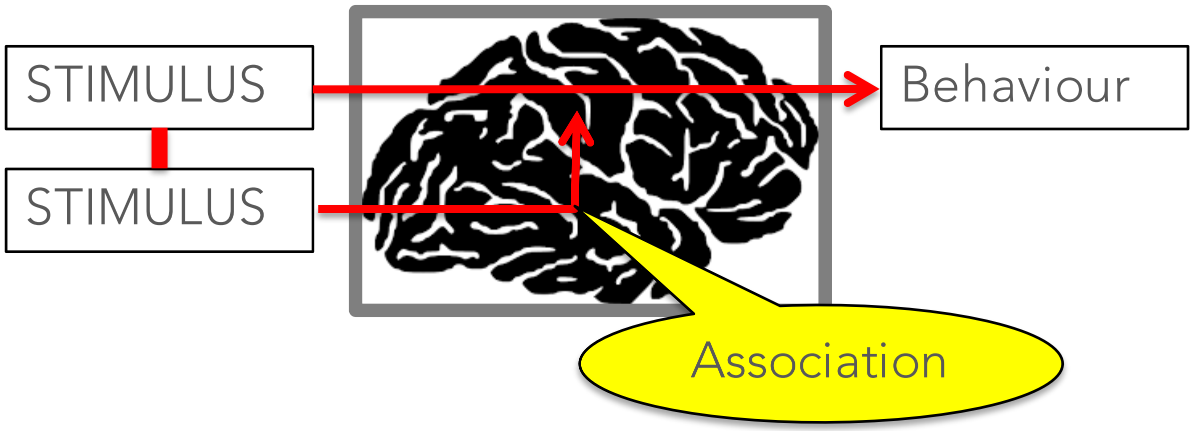
Chapter 6: Constructivism:

From Piaget to Augmented Reality

Pierre Dillenbourg and Patrick Jermann, Łukasz Kidziński

Reminder of Chapter 3: **Behaviorism**

How do people learn ? By conditionning

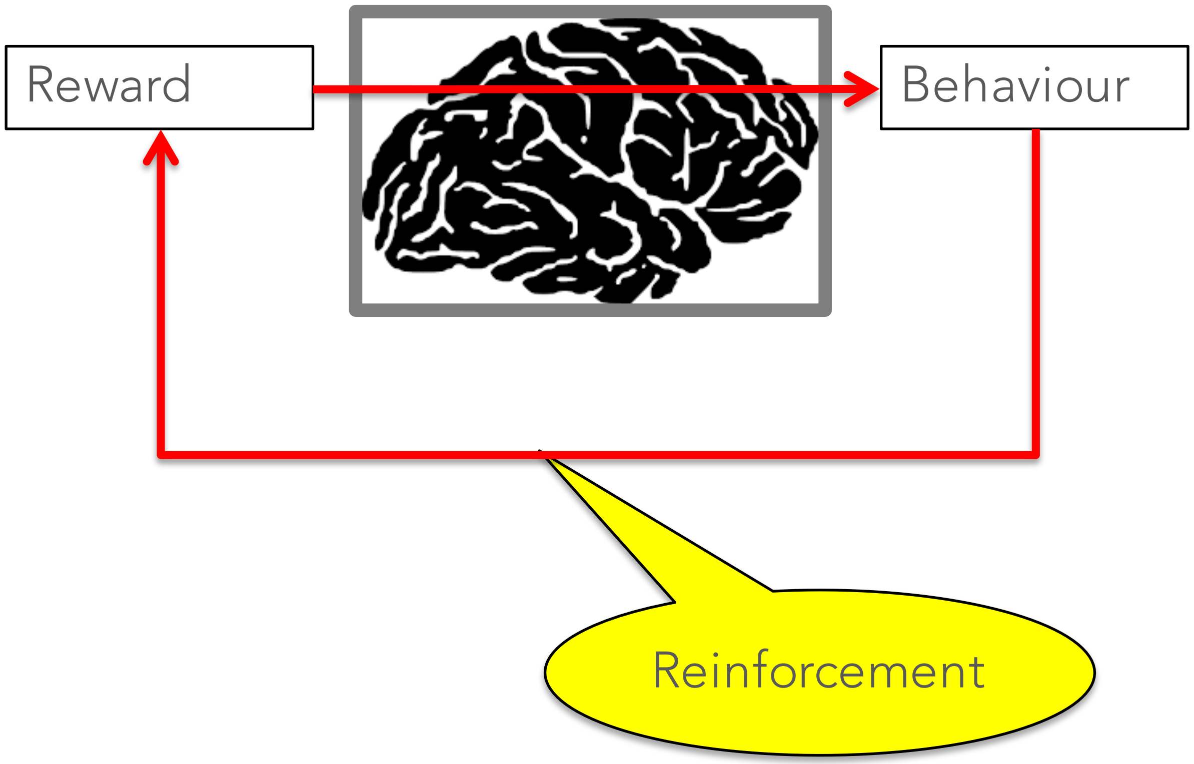


p (B | S)

analytics

Reminder of Chapter 2: **Behaviorism**

How do people learn ? By reinforcement

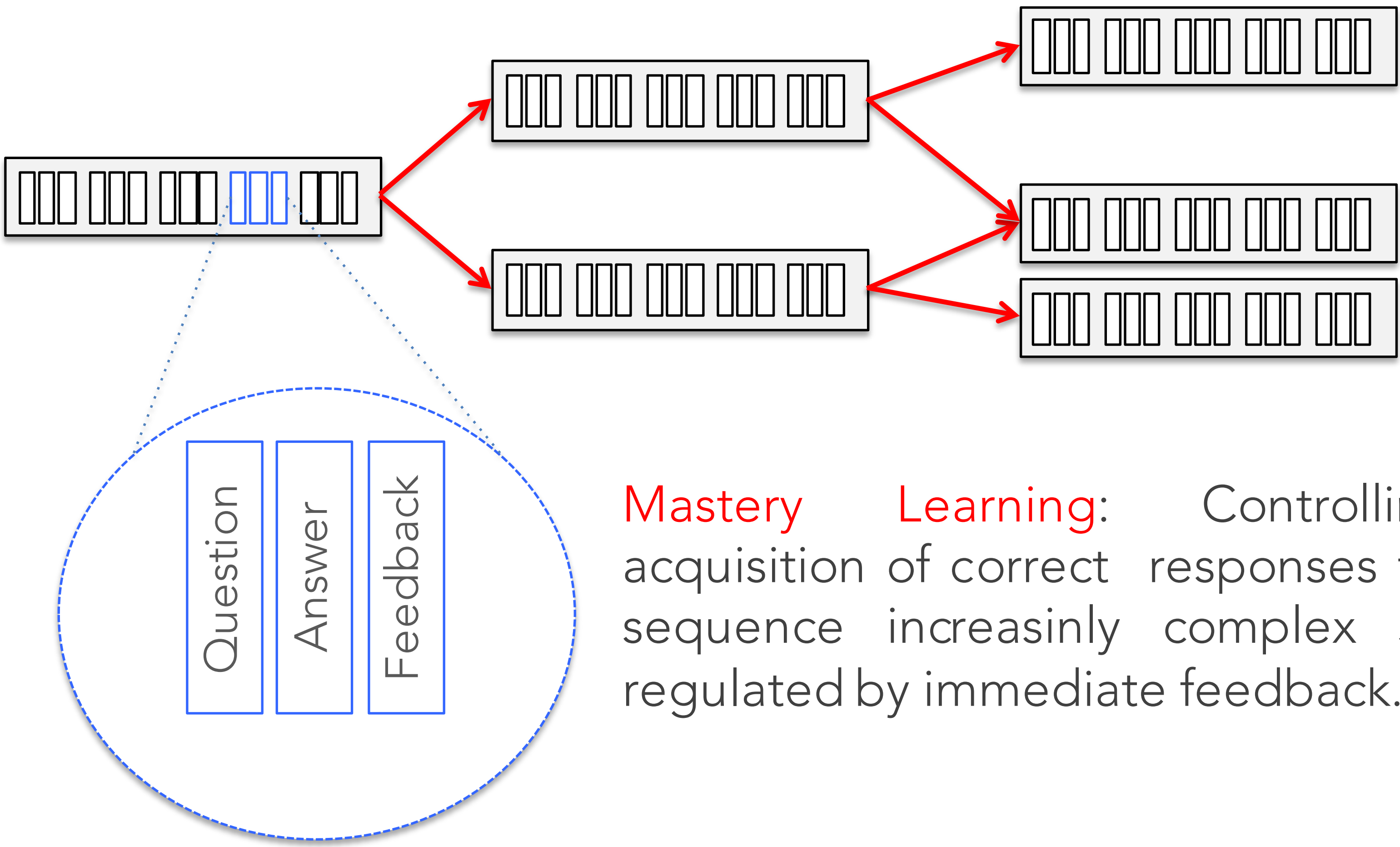


How do people learn ? → Which technology for learning ?

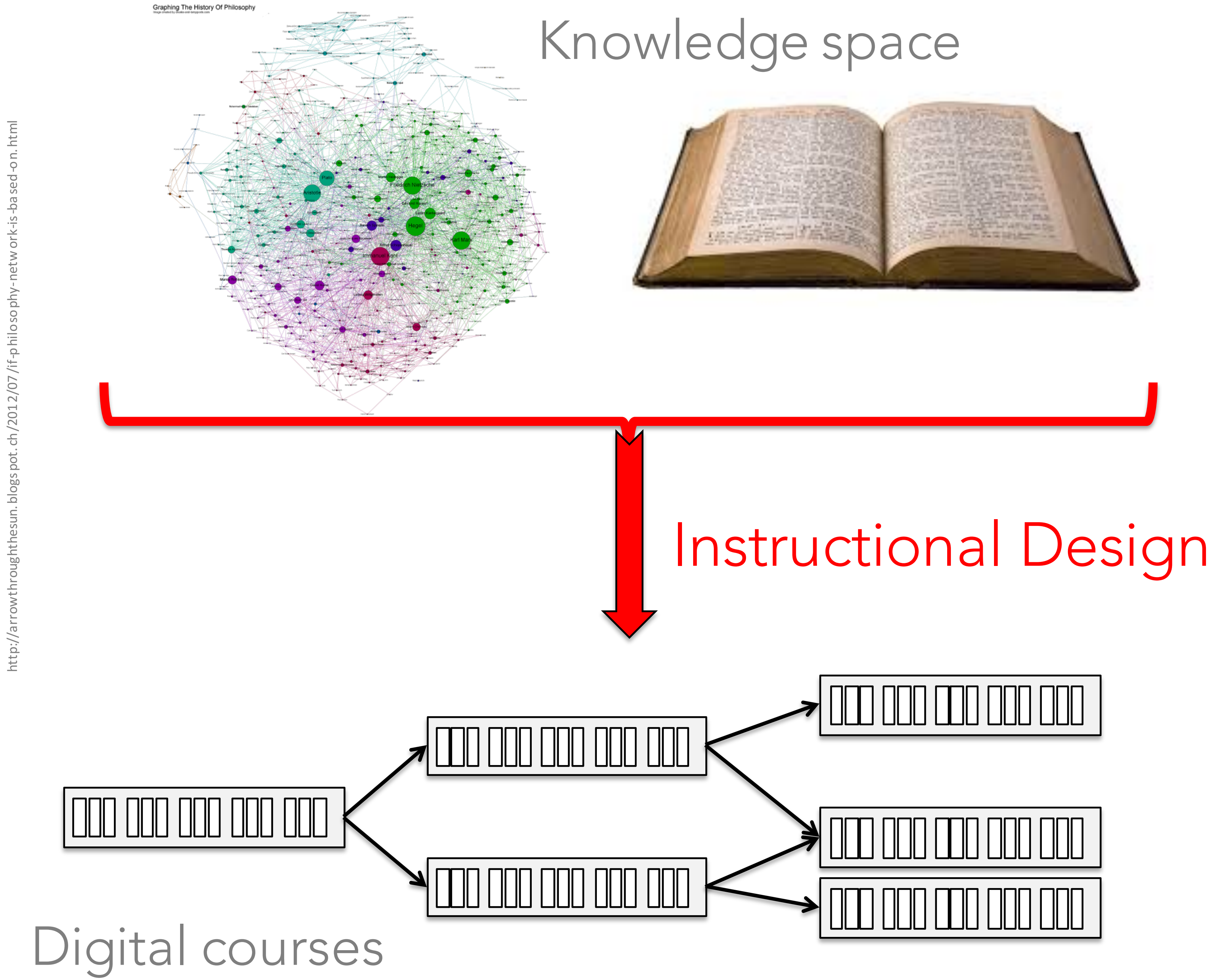
Reminder of Chapter 2: **Behaviorism**

How do people learn ? ➔ Which technology for learning ?

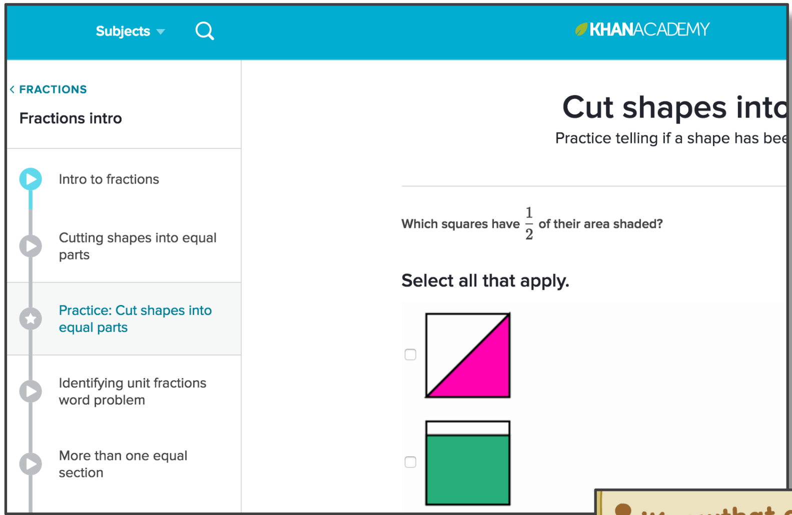
Drill & Pratice, Courseware, e-Learning



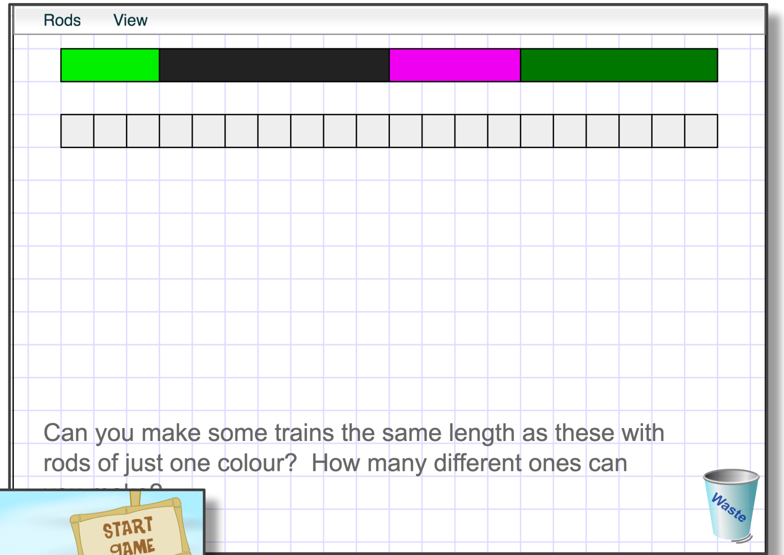
Mastery Learning: Controlling the acquisition of correct responses through a sequence increasinly complex situations, regulated by immediate feedback.


Graphing The History Of Philosophy
Knowledge space
Instructional Design
Digital courses
http://arrowthroughthesun.blogspot.ch/2012/07/if-philosophy-network-is-based-on.html

Learning Fractions: Comparing 3 methods



https://www.khanacademy.org/



http://nrich.maths.org/4332

http://streaming.discoveryeducation.com/braingames/iknowthat/Fractions/FractionGame.cfm?Topic=namematch

Lesson A

A **splountz** is a triangle with 3 smaller shapes placed on different sides, one in the same color as the triangle and the two others in a different color.

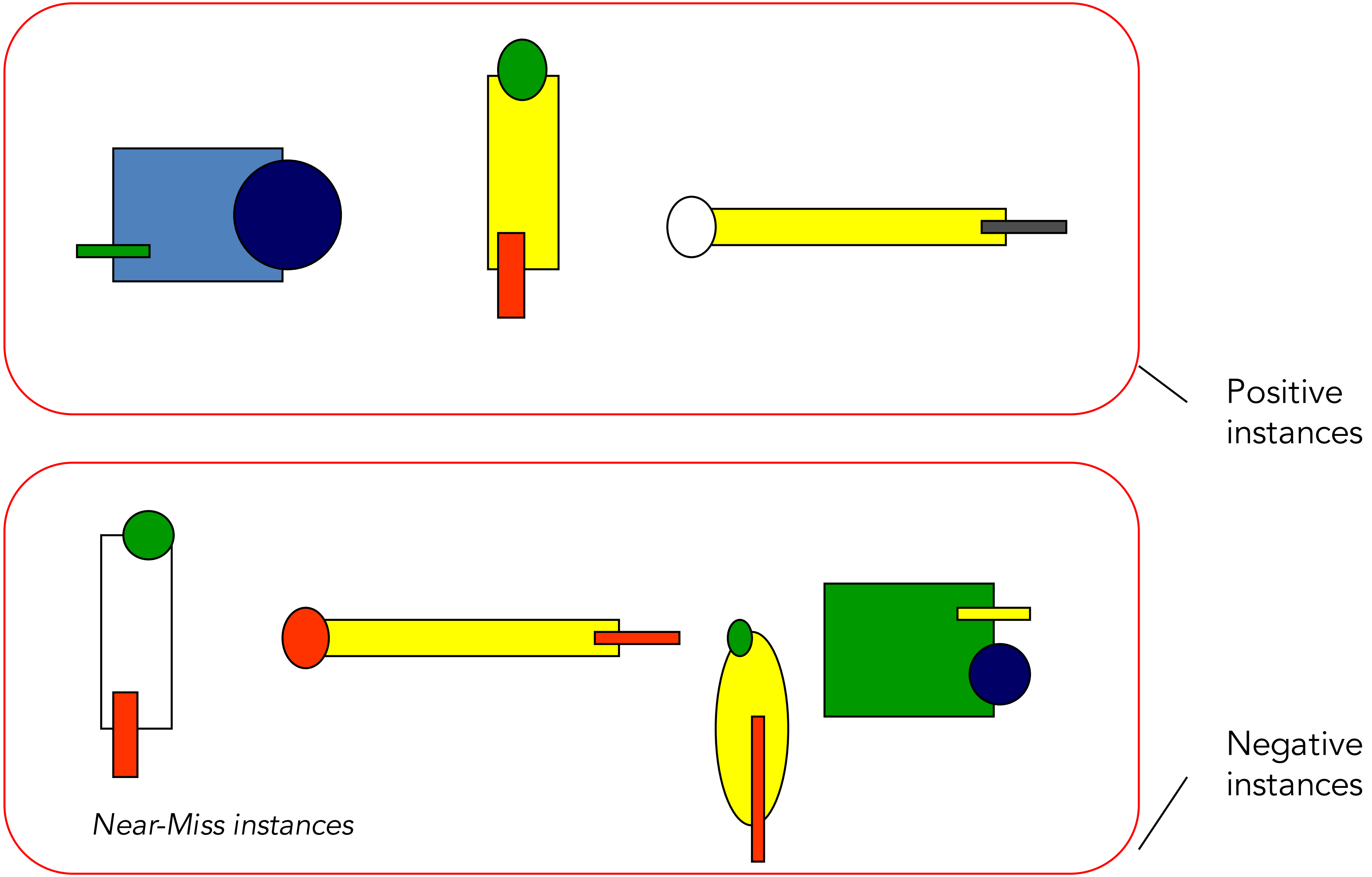
Is this a Splountz ?

○ Yes

✔ ○ No

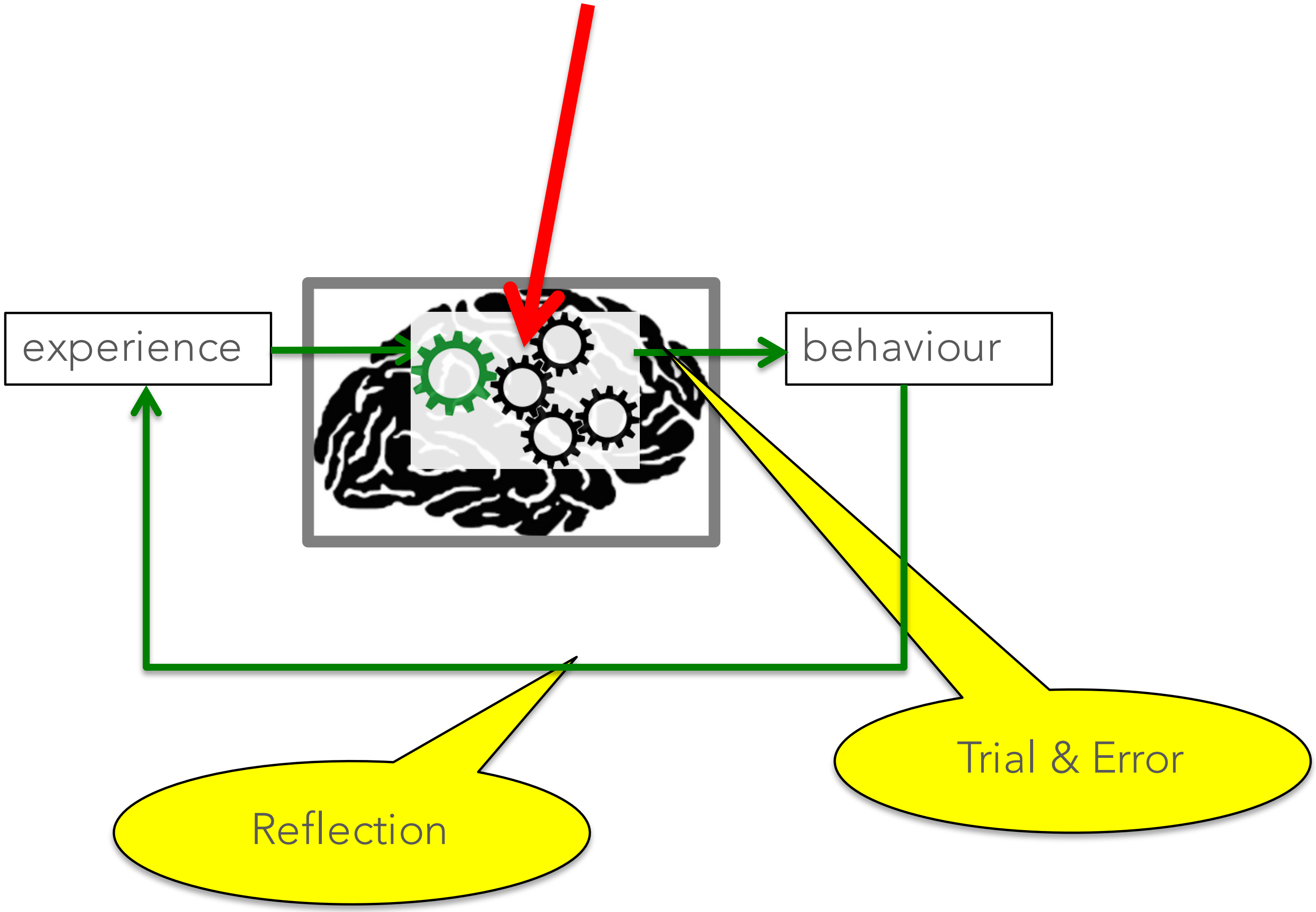
Lesson B

WHAS IS A SPUC ?



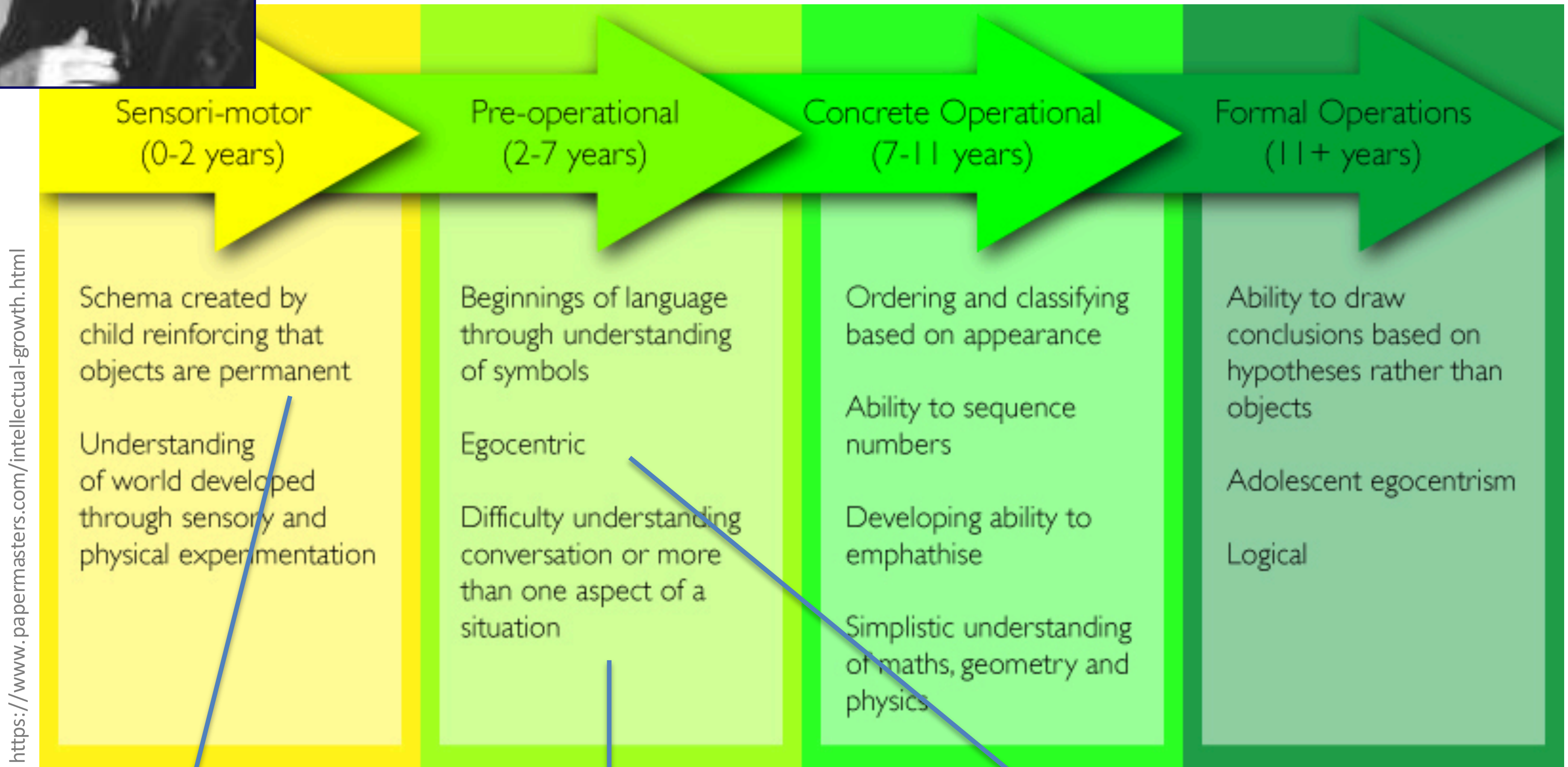
Chapter 6: **Constructivism**

How do people learn ? By constructing cognitive structures from experience (trial & error)



Jean Piaget

Stages of development



[Permanence of object]

[Conservation Task]

[PryramidTask]

Jean Piaget

Assimilation and Accommodation

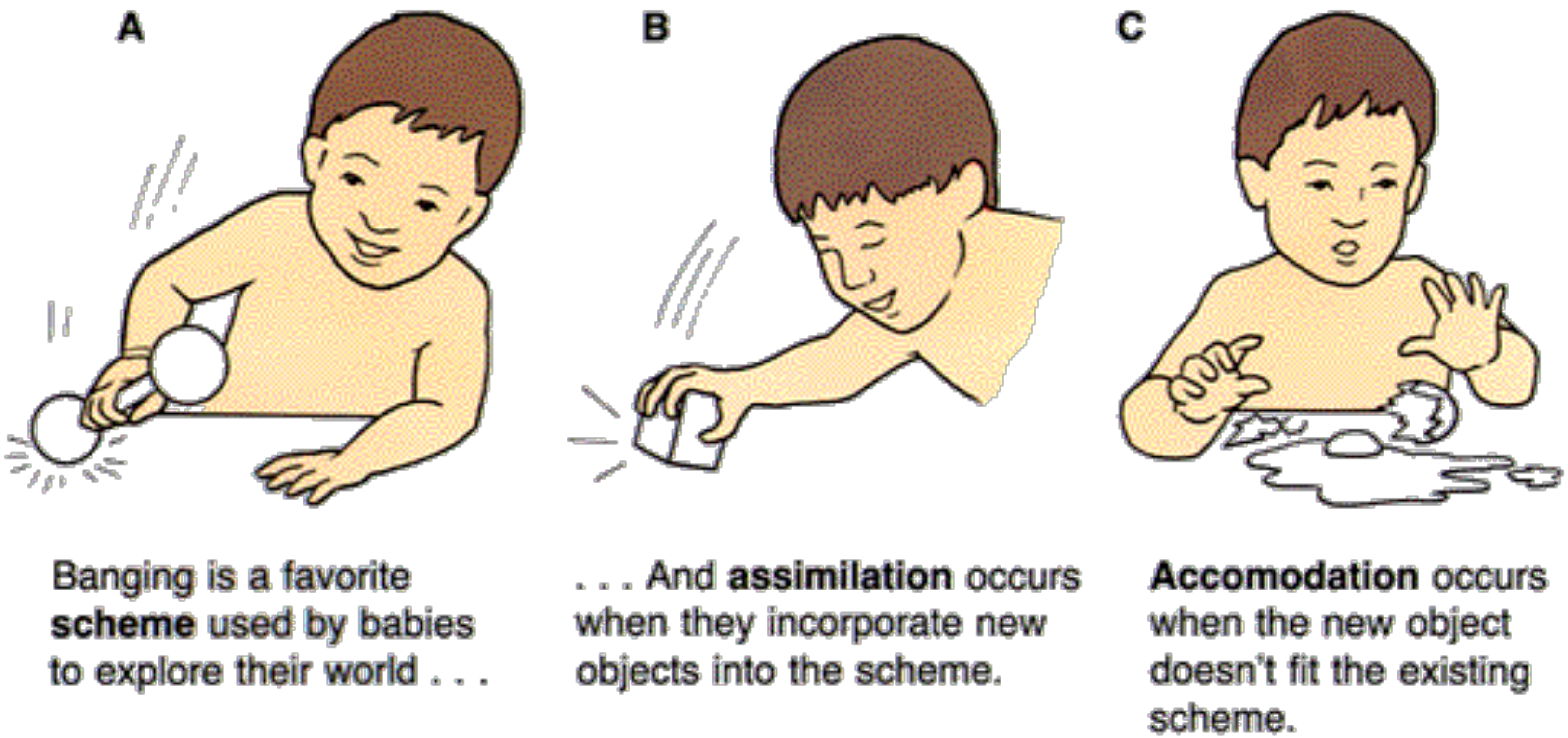
How can this girl use her "dog" schema when encountering a cat?

- She can **assimilate** the experience into her schema by referring to the cat as a "dog"

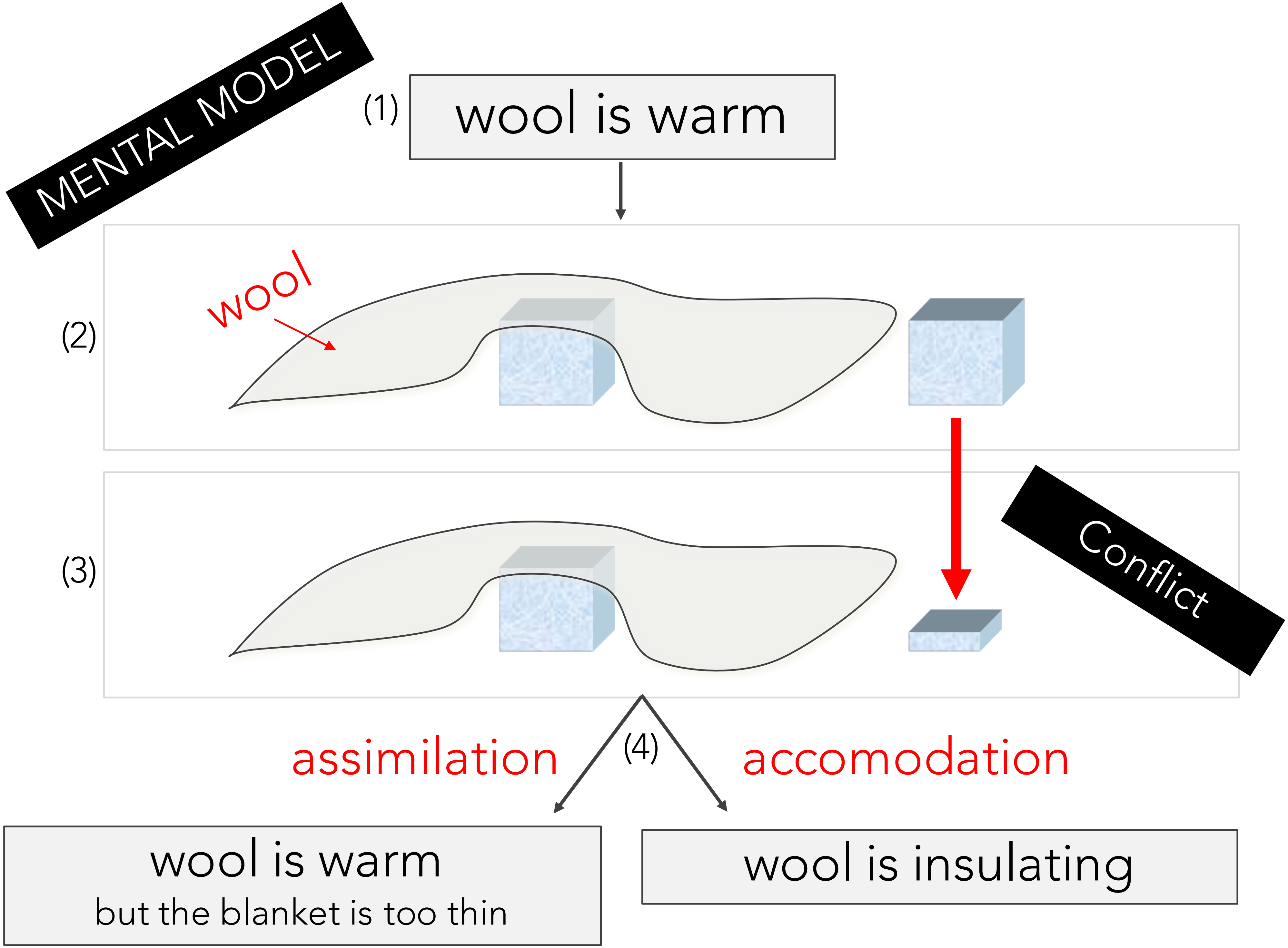
or

- she can **accommodate** her animal schema by separating the cat, and even different types of dogs, into separate schemas.

http://www.enkivillage.com/assimilation.html



Piaget (1952) defined a schema as 'a cohesive, repeatable action sequence possessing component actions that are tightly interconnected and governed by a core meaning'. Basically, a scheme is the building block of intelligent behavior


MENTAL MODEL
(1)
wool is warm
(2)
wool
(3)
Conflict
(4)
assimilation
accomodation
wool is warm
but the blanket is too thin
wool is insulating

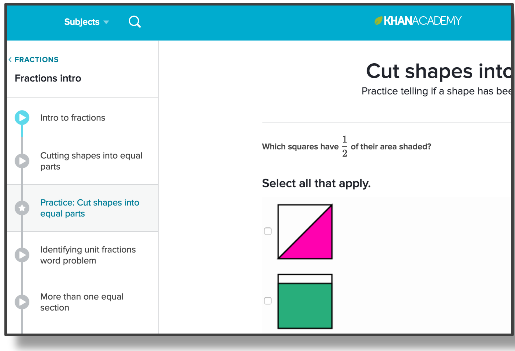
Cognitive Conflict
as key learning mechanism

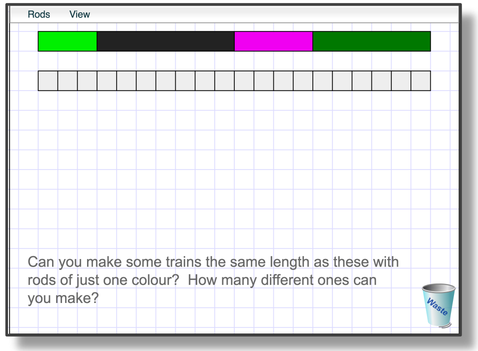
- Learning from experience
- Learning by doing
- Discovery learning

Constructivism ≠ Teacherless

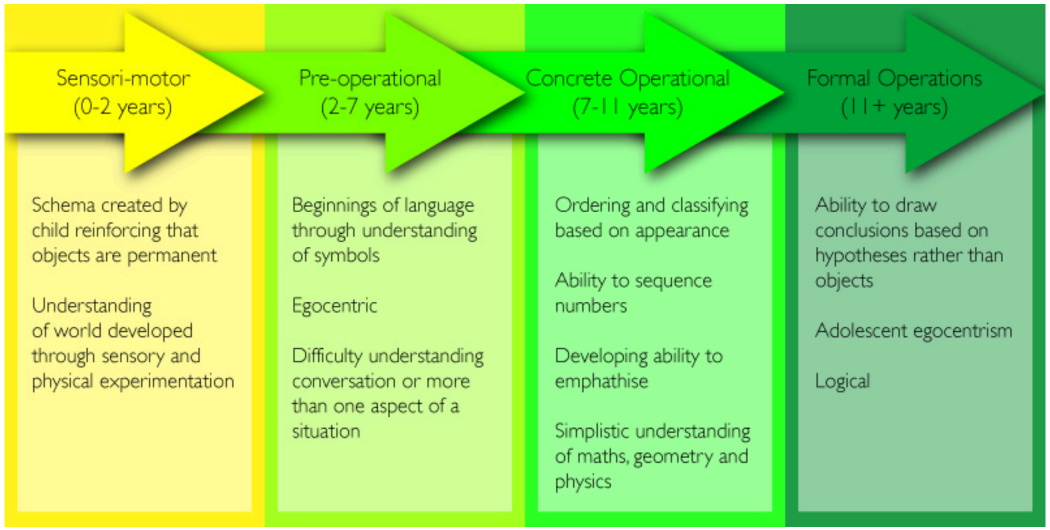
You experienced the constructivist method
« Contrasting Cases »

1

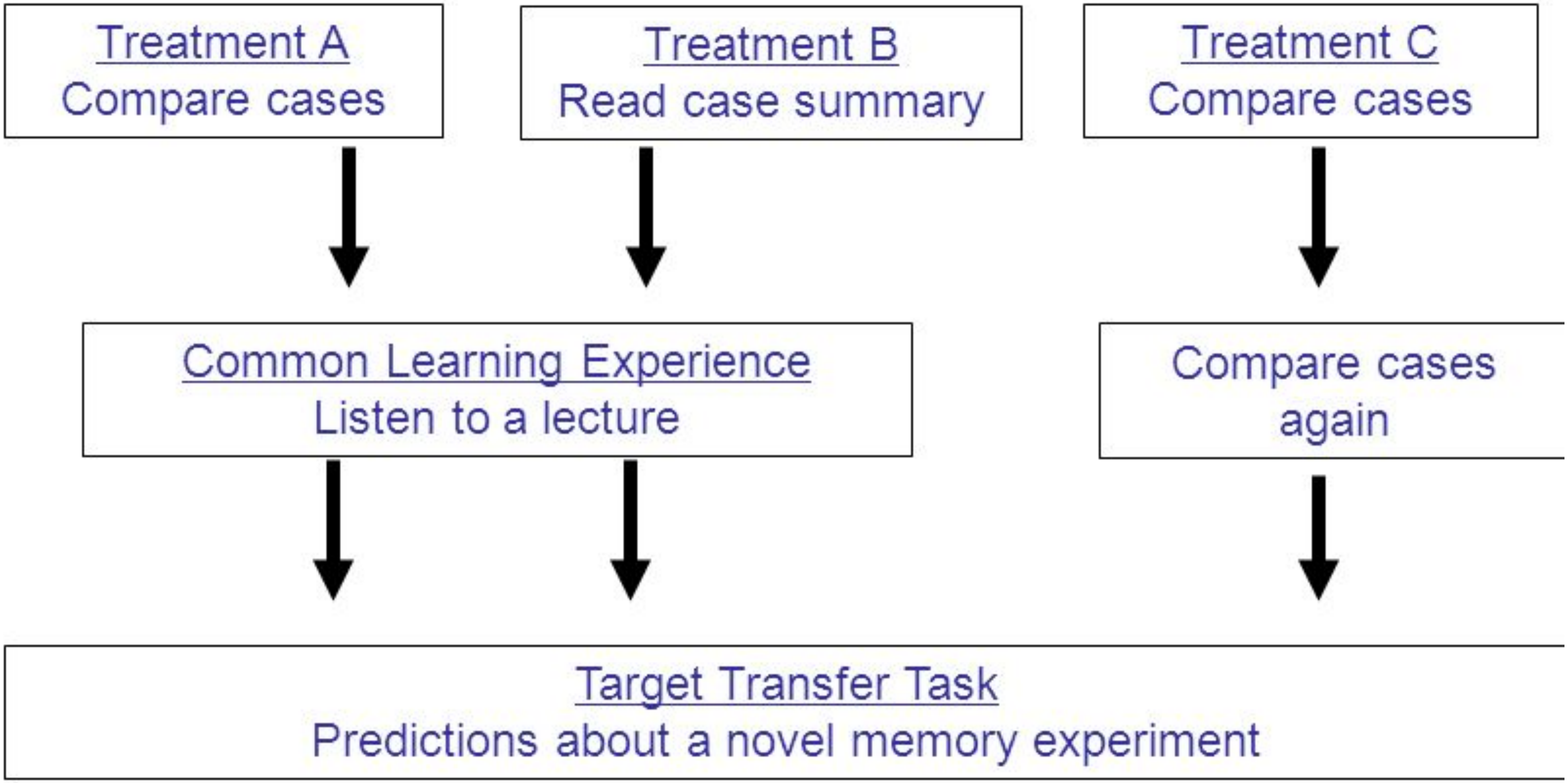




2



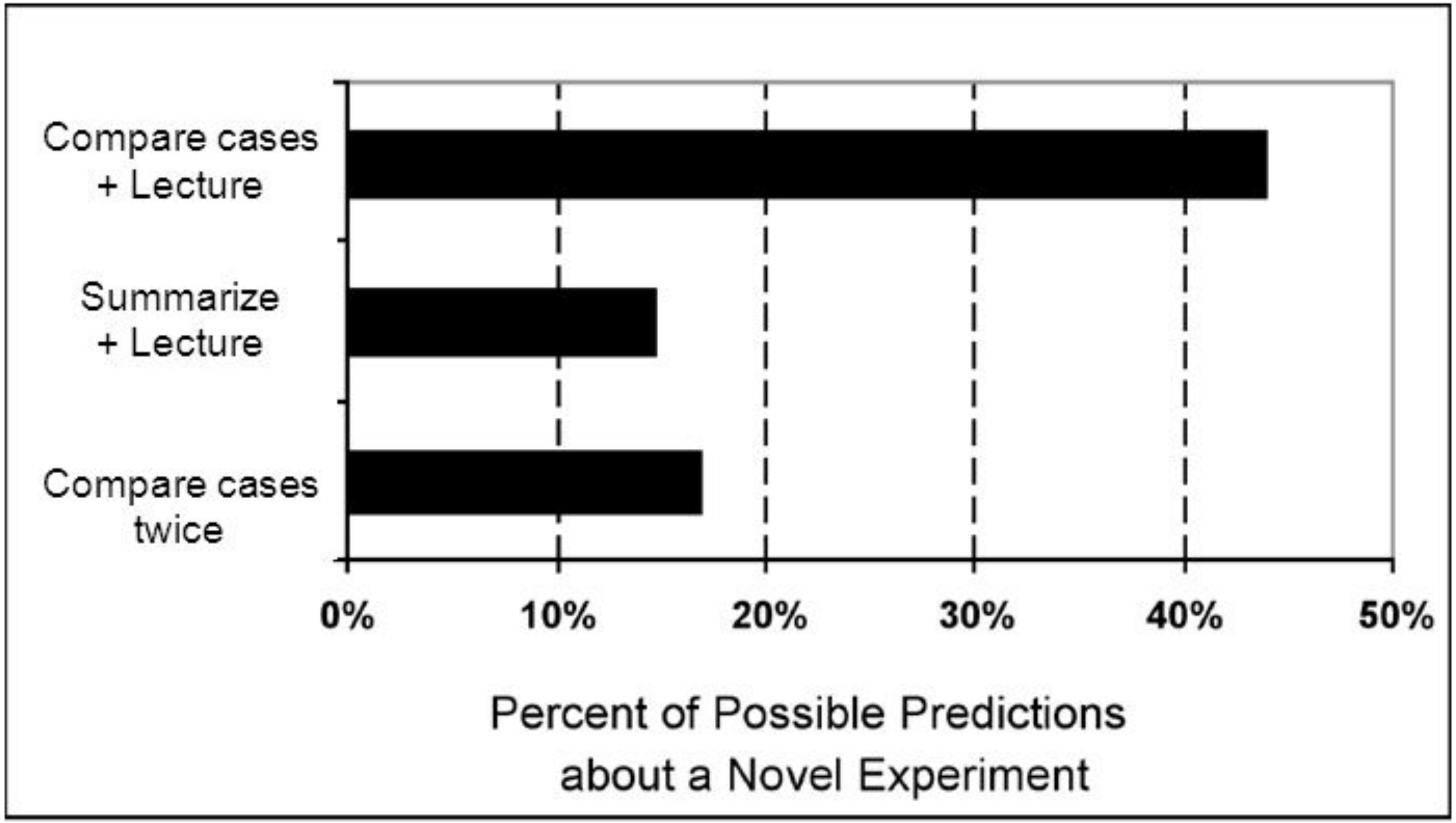
« Contrasting Cases »



Daniel L. Schwartz & John D. Bransford (1998) A Time For Telling, Cognition and Instruction, 16:4, 475-5223, DOI: 10.1207/s1532690xci1604_4

Lucinda Kelly

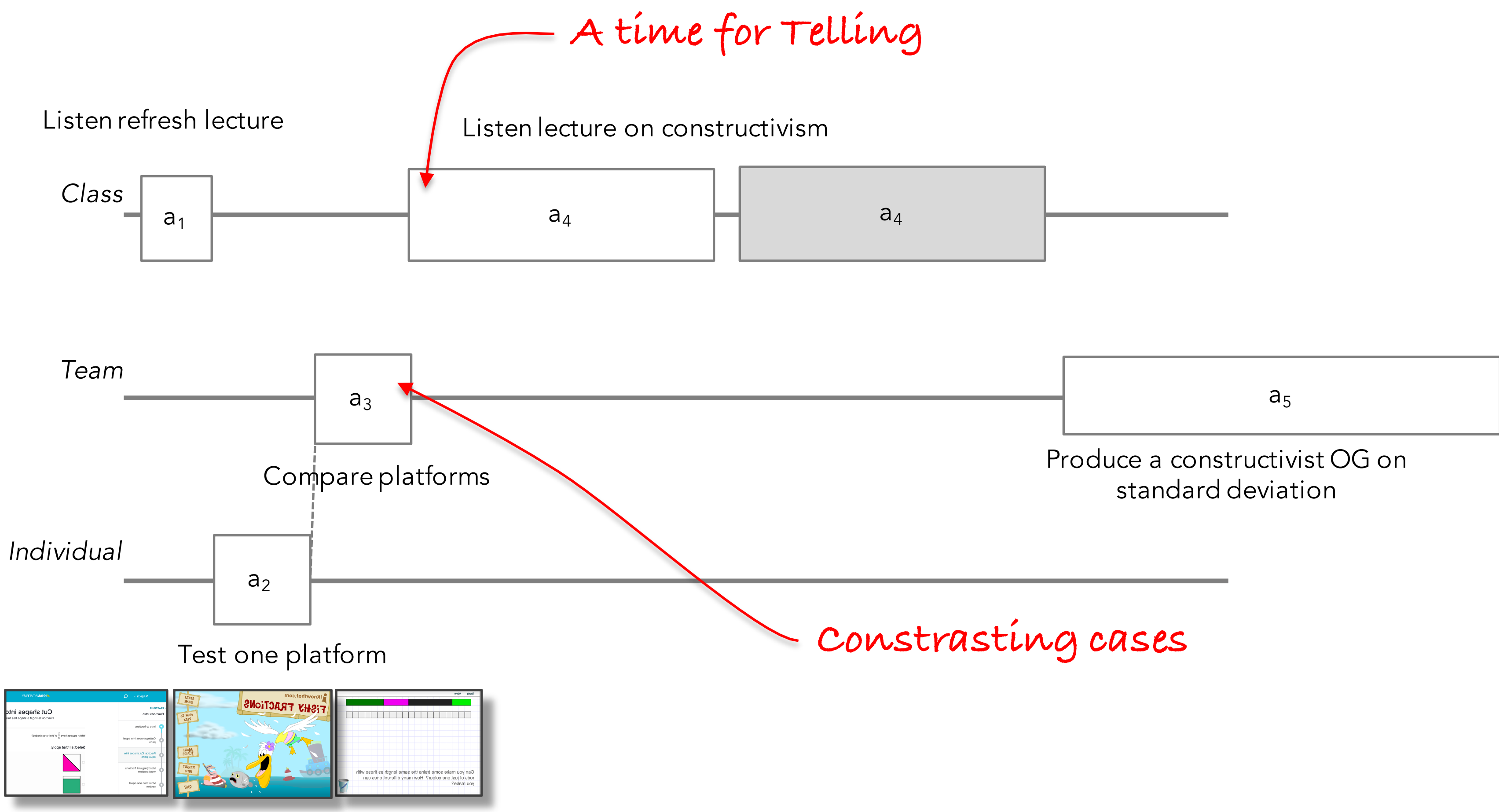
« Contrasting Cases »



COGNITION & SCIENCE INSTRUCTION

Lucinda Kelly

Today's Orchestration Graph



Collect knowledge

“Produtive Failure”

Who’s the most consistent striker?

Year	Mike Arwen	Dave Backhand	Ivan Right
1988	14	13	13
1989	9	9	18
1990	14	16	15
1991	10	14	10
1992	15	10	16
1993	11	11	10
1994	15	13	17
1995	11	14	10
1996	16	15	12
1997	12	19	14
1998	16	14	19
1999	12	12	14
2000	17	15	18
2001	13	14	9
2002	17	17	10

Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. *Journal of the Learning Sciences*, *21*(1), 45-83.

Mike Arwen : Mean = $\frac{280}{20}$

= 14 goals /year

Mode = 14

Dave Backhand : Mean = $\frac{280}{20}$

= 14 goals / year

Mode = 14

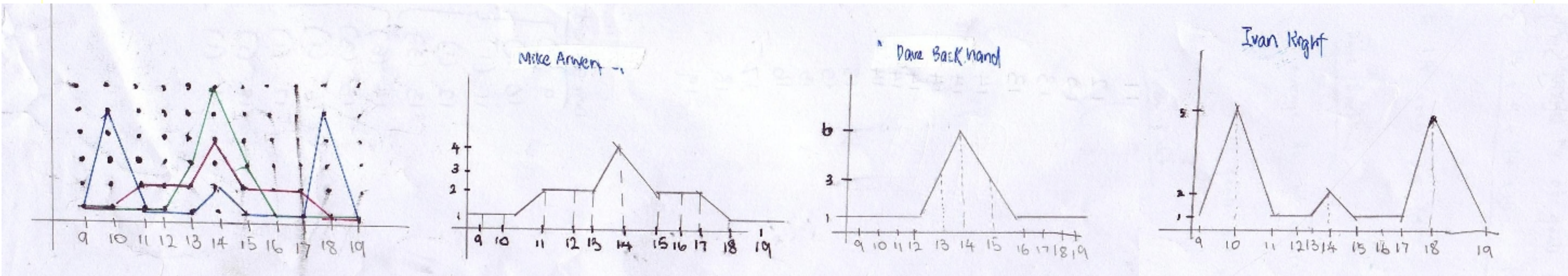
Ivan Right : Mean = $\frac{280}{20}$

= 14 goals / year

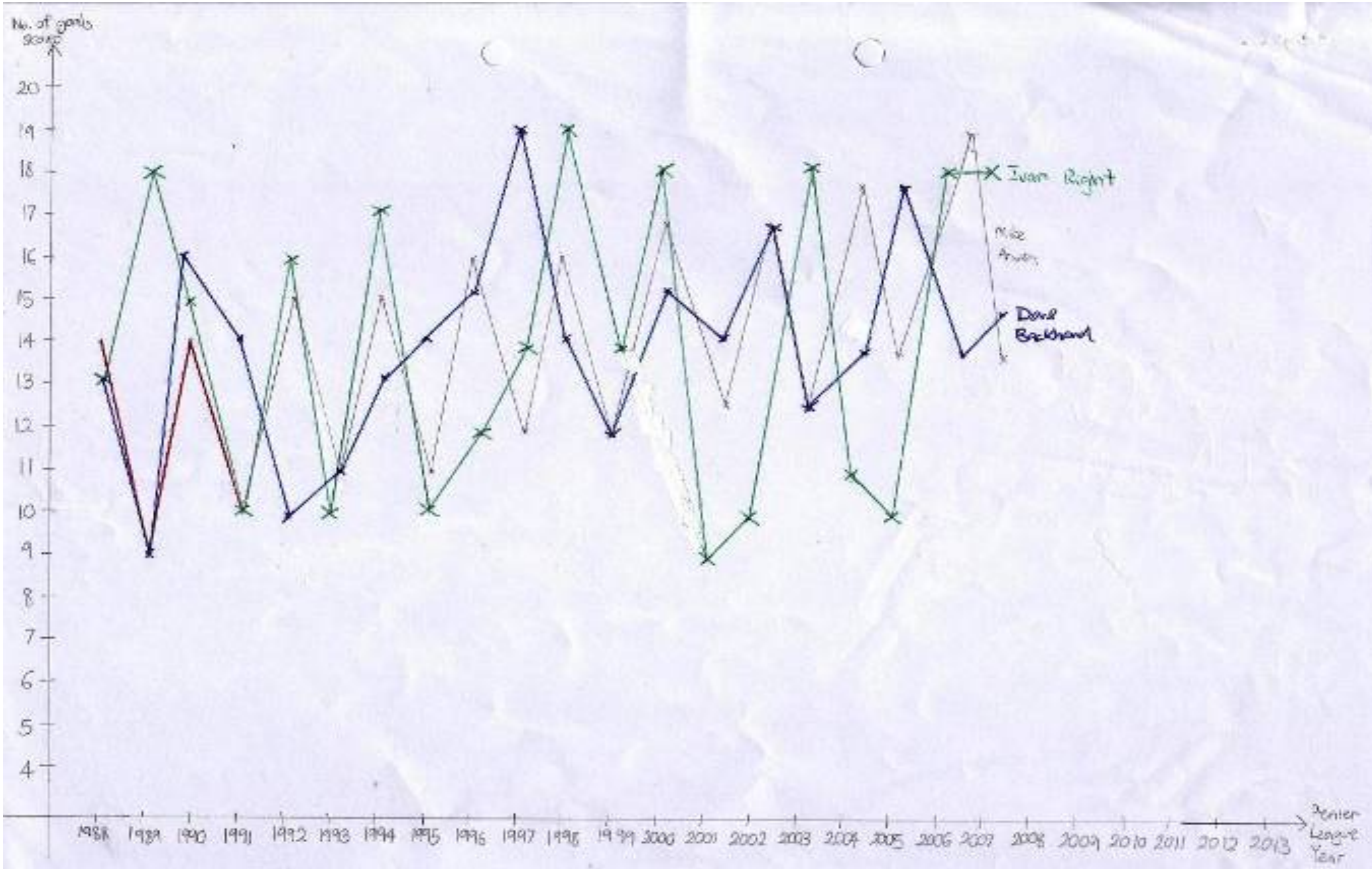
Mode = 18 and 10

comparing regularity

9	10	11	12	13	14	15	16	17	18	19
1	1	2	2	2	4	2	2	2	1	1
1	1	1	1	3	6	3	1	1	1	1
1	5	1	1	1	2	1	1	1	5	1



9 10 11 11 12 12 13 13 14 14 14 14 15 15 16 16 17 17 18 19



Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. *Journal of the Learning Sciences*, *21*(1), 45-83.

From Question paper: Average = $\frac{280}{20}$

Mike has 8 years < average

4 years = average

8 years > average

Dave has 7 years < average

6 years = average

7 years > average

Ivan has 9 years < average

2 years = average

9 years > average

Frequency of years above, below, and at average

Consistency = years at the mean / years away from the mean

Sum of year-on-year deviation

Mike	Dave	Ivan
9-14 = -5	-4	5
14-9 = 5	7	-3
10-14 = -4	-2	-5
15-10 = 5	-4	1
-4	1	-6
4	2	7
-4	1	-7
5	1	2
-4	4	2
4	-5	5
-4	-2	-5
5	3	4
-4	-1	-9
4	3	1
-4	-4	8
5	1	-7
-4	4	-1
5	-4	8
-4	1	0
0 ✓ mike	-2	-5

Range ~~Mode~~ amount for:

Mike Arwen: 9 — 19 = 10

Dave Buckland: 9 — 19 = 10

Ivan Right: 9 — 19 = 10

X

Sum of deviations about the mean

Year	Avg	M.A	D.B	I.R	X		
1988	14	14	13	13	0,	-1,	-1
1989	14	9	14	18	-5,	-5,	4
1990	14	14	16	15	0	+2,	+1
1991	14	10	14	10	-4	0	-4
1992	14	15	10	16	+1	-4	+2
1993	14	11	11	10	-3	-3	-4
1994	14	15	13	17	+1	-1	+3
1995	14	11	14	10	-3	0	-4
1996	14	16	15	12	+2	+1	-2
1997	14	12	19	14	-2	+5	0
1998	14	16	14	19	+2	0	+5
1999	14	12	12	14	-2	-2	0
2000	14	17	15	18	+3	+1	+4
2001	14	13	14	9	-1	0	-5
2002	14	17	17	10	+3	+3	-4
2003	14	13	13	18	-[illegible]	-1	+4
2004	14	18	14	11	+4	0	-3
2005	14	14	18	10	0	+4	-4
2006	14	19	14	18	+5	0	+4
2007	14	14	15	18	0	+1	+4
				Total:	[illegible]	[illegible]	[illegible]

Average of year-on-year absolute deviation

$$\text{MIKE} = \frac{5+5+4+5+4+4+4+5+4+4+4+5+4+4+4+5+4+5+4}{20-1}$$

$$= 84/19 = 4.26$$

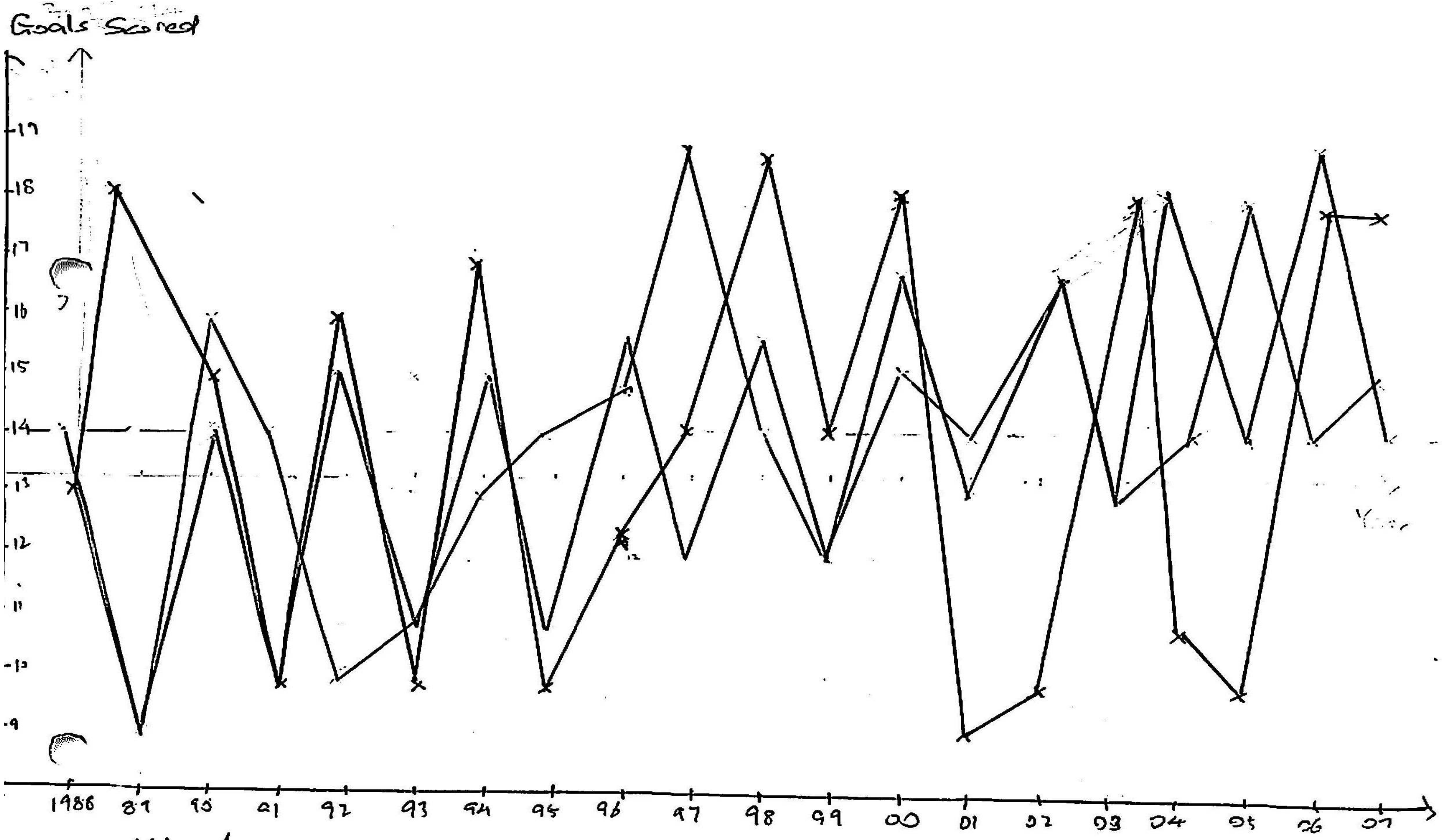
$$\text{DAVE} = \frac{4+7+2+4+1+2+1+1+4+5+2+3+1+3+4+1+4+4+1}{19}$$

$$= 54/19 = 2.84$$

DAVE [illegible] is most consistent

$$\text{IVAN} = \frac{5+3+5+1+6+7+7+2+2+5+5+4+9+1+8+7+1+8+0}{19}$$

$$= 4.79$$



— Mike Arwen
— Dave Backhand
— Ivan Right

Idea 3 Measure Graph Length

MA $\sqrt{26}+\sqrt{26}+\sqrt{17}+\sqrt{26}+\sqrt{17}+\sqrt{17}+\sqrt{17}+\sqrt{26}+\sqrt{10}+\sqrt{10}+\sqrt{10}+\sqrt{26}+\sqrt{17}+\sqrt{17}+\sqrt{17}+\sqrt{26}+\sqrt{17}+\sqrt{26}+\sqrt{26}=83.26$

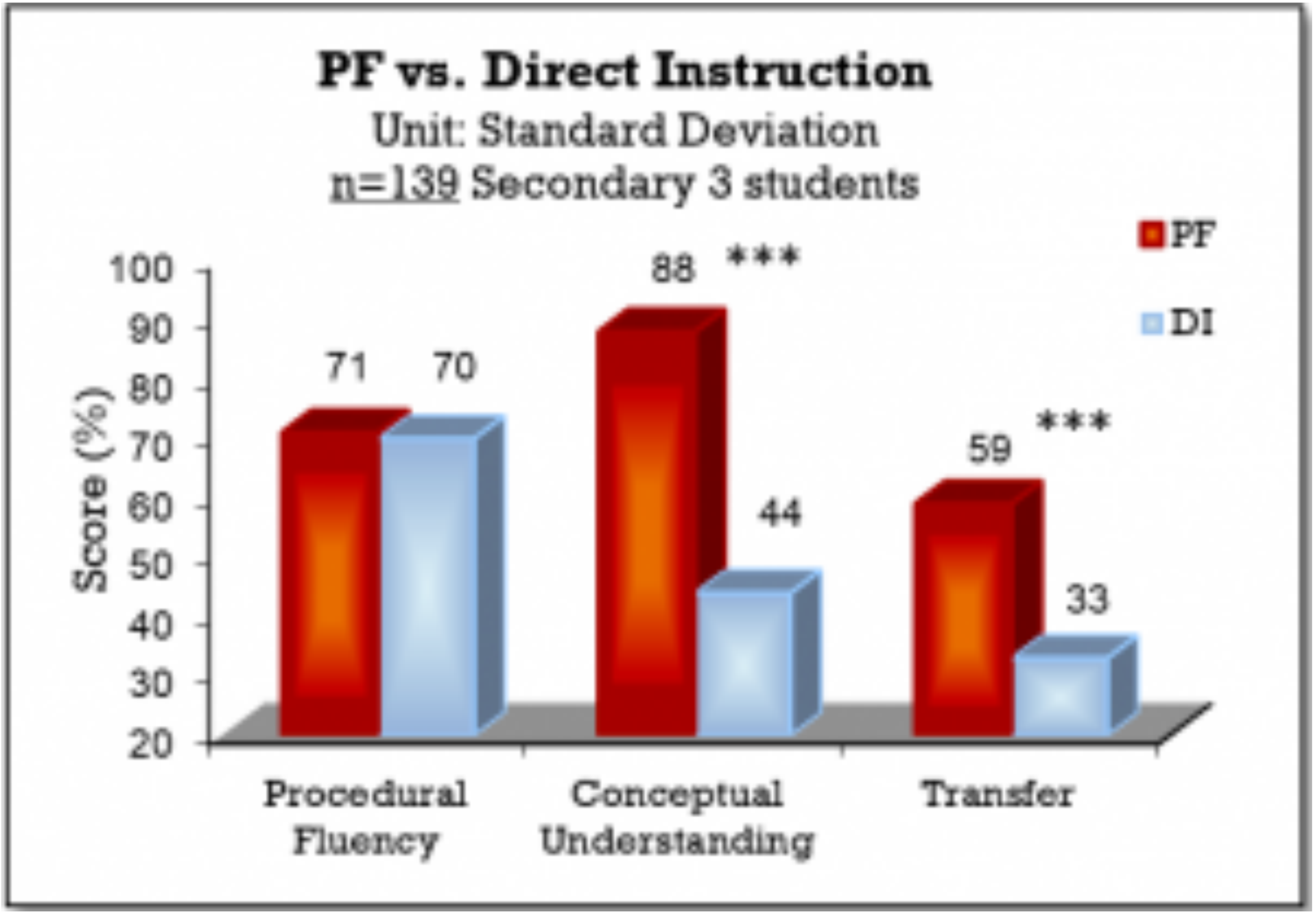
DB $\sqrt{17}+\sqrt{50}+\sqrt{5}+\sqrt{17}+\sqrt{5}+\sqrt{5}+\sqrt{2}+\sqrt{2}+\sqrt{17}+\sqrt{26}+\sqrt{5}+\sqrt{10}+\sqrt{2}+\sqrt{5}+\sqrt{10}+\sqrt{2}+\sqrt{17}+\sqrt{17}+\sqrt{2}=56.54$

IR $\sqrt{26}+\sqrt{10}+\sqrt{26}+\sqrt{37}+\sqrt{37}+\sqrt{50}+\sqrt{50}+\sqrt{5}+\sqrt{5}+\sqrt{26}+\sqrt{26}+\sqrt{17}+\sqrt{82}+\sqrt{2}+\sqrt{65}+\sqrt{50}+\sqrt{2}+\sqrt{65}+1=94.54$

∴ Dave Backhand is the most consistent player as he has the shortest 'stretched-out' graph, showing consistency over time.

Azaac Aikeen

3



Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. *Journal of the Learning Sciences*, *21*(1), 45-83.

How do people learn ? ➔ Which technology for learning ?

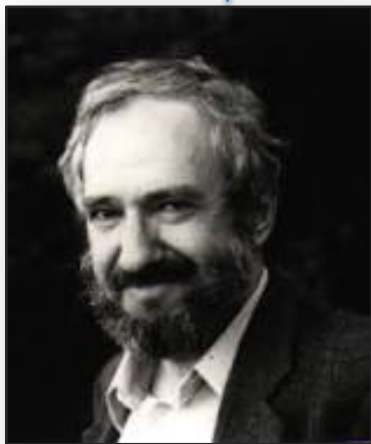
Jean Piaget

Scheme

If I cannot reach object A, I can take object B that connects my hand to A

Object to think with

To implement a complex program, I can decompose it into sub-problems



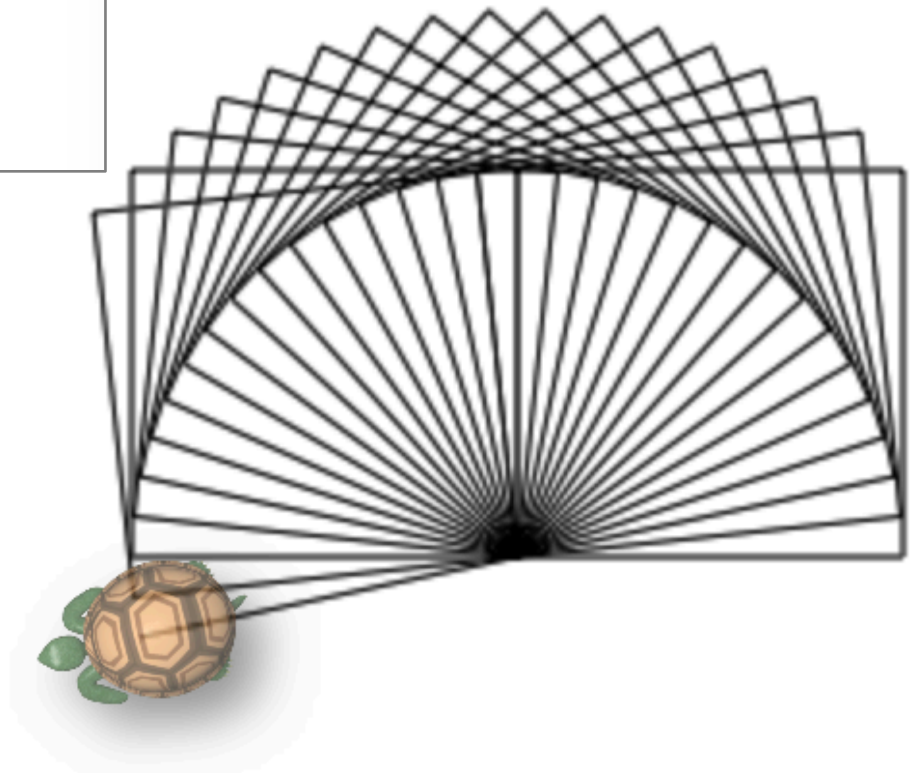
Seymour Papert

Function/method in programming language

« MICROWORLD »

ExoLogO

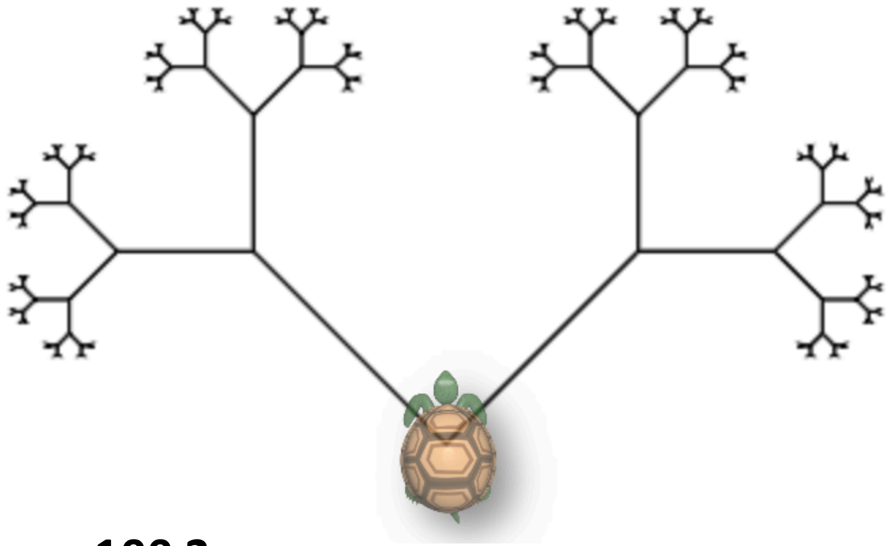
```
define "carre [[size]
[repeat 4 [forward :size wait 0.1  right 90]]]

define "fleur [[size]
[clean repeat 60 [carre :size left 6]]]


fleur 100
```



http://www.alancsmith.co.uk/logo/

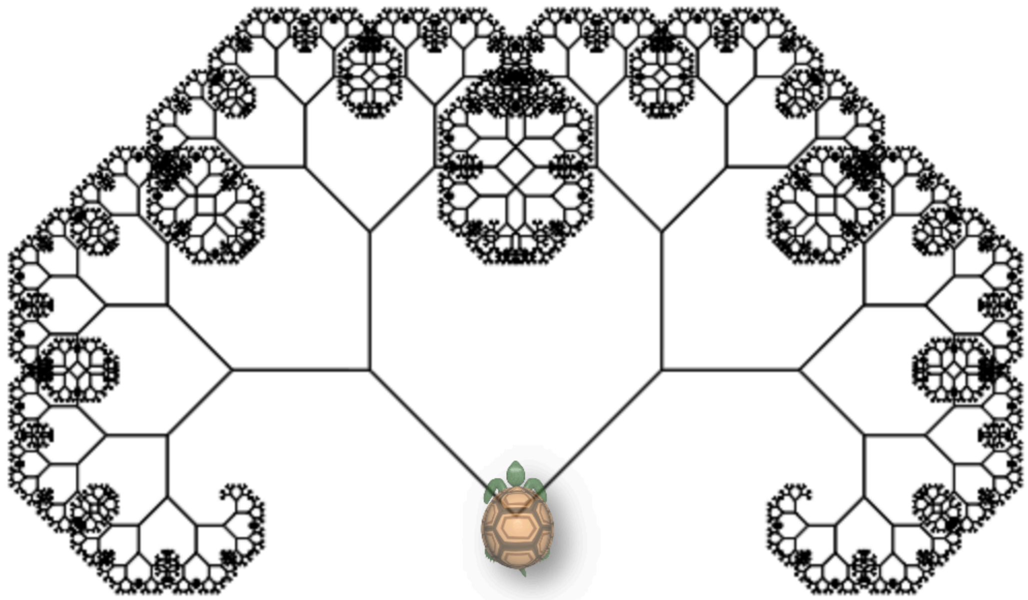
Papert, S. & Solomon, C. (1971, Twenty things to do with a computer, AI Memo 248, MIT

```
define "Zum [[length divider]
        [if :length < 1
          [stop]
         [     left 45
               forward :length
               zum :length/:divider  :divider
               back :length
               right 90
               forward :length
               zum :length/:divider  :divider
               back :length
               left 45
               ]
        ]
]]
```



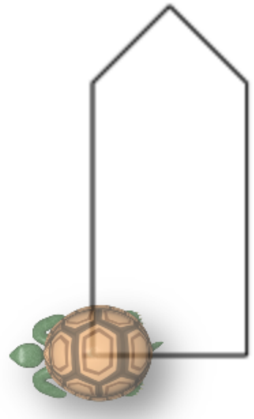
zum 100 2

zum 100 1.5

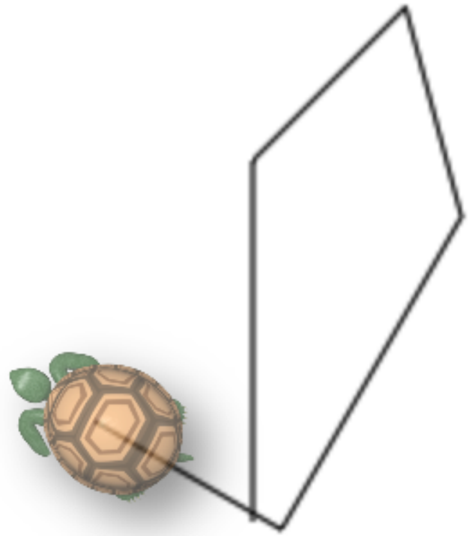


Cognitive Conflict
as key learning mechanism

(1) I wanted to get this



(2) I got that



```
define "house1 [[ ]
        [forward 100
         right 45
        forward 60
        right 120
        forward 60
        right 45
        forward 100
        right 90
        forward 60
        ]]
```

(3) The problem is here

METACOGNITION

Cognitive Conflict
as key learning mechanism

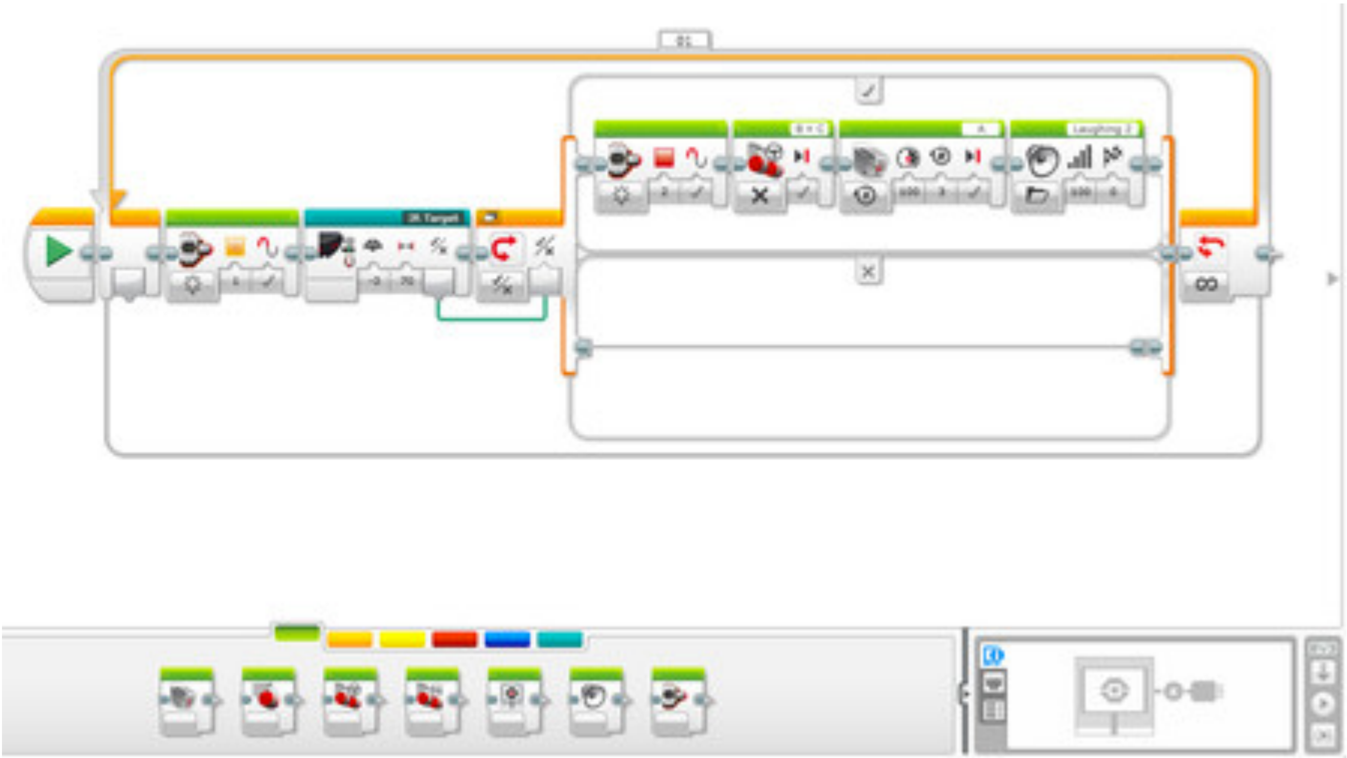
- Learning from experience
- Learning by doing
- Learning from failure
- Discovery learning

Conditions:

1. The conflict is detected
2. The learner finds how to solve it

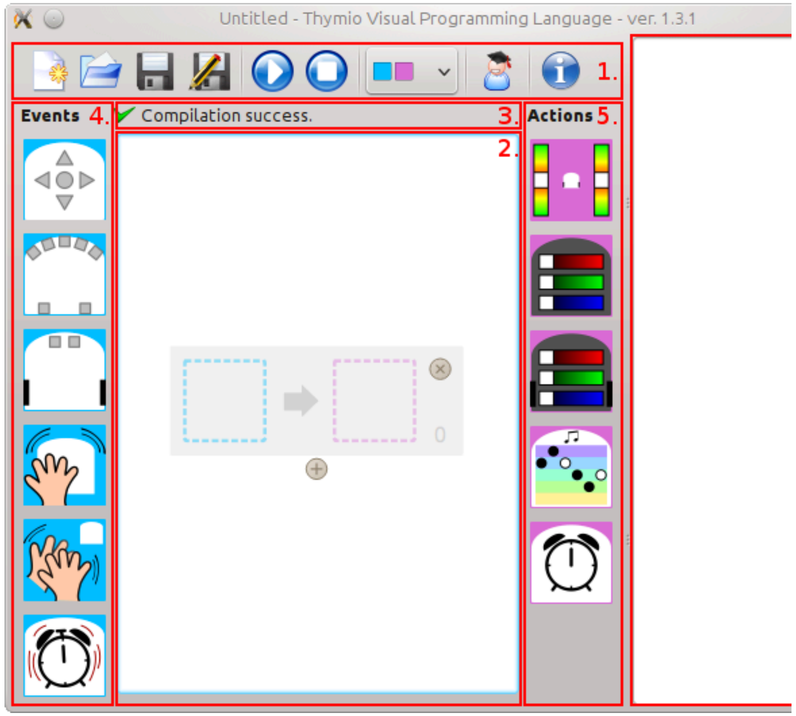
Role of the environment (sequence of projets / teacher / peer)

constructivism ➔ constructionnism



http://www.srf.ch/wissen/digital/lego-mindstorms-ev3-ein-neues-hirn-fuer-komplexere-roboter

THYMIO



https://aseba.wikidot.com/fr:thymiovpl

https://www.youtube.com/watch?v=8RiEDT8bsOs

http://guerrillamakerspace.squarespace.com/space-4/

constructivism ➔

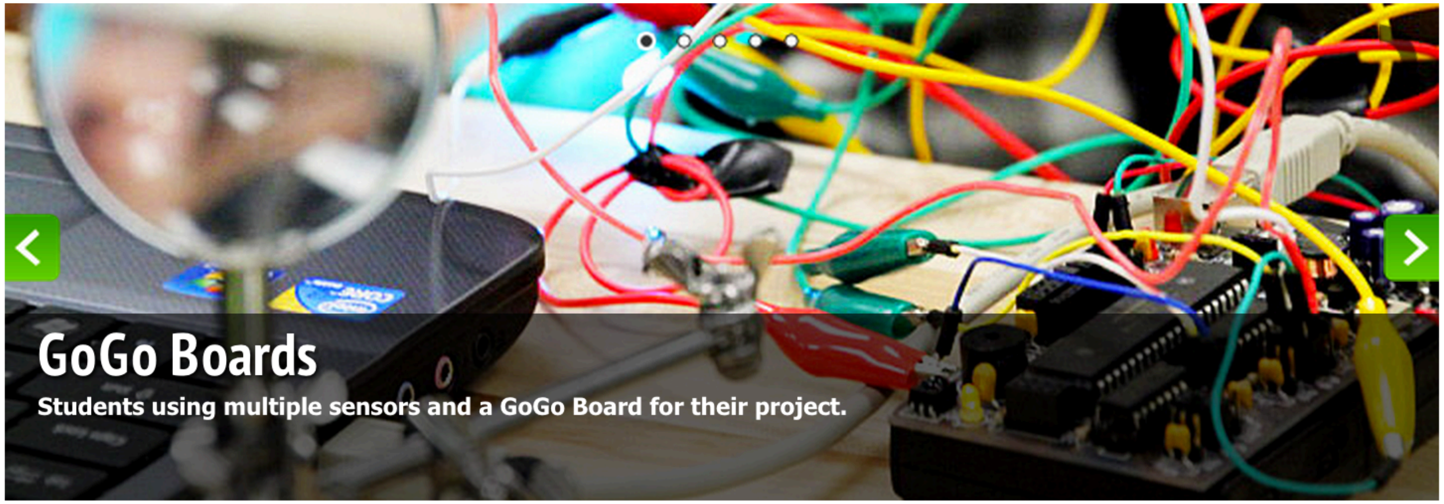
constructionnism

http://fablabatschool.org/

FabLab@School

Digital Fabrication
and Hands-on Learning in Education

About Blogs Photos Projects Resources



FabLab@School

A growing network of educational digital fabrication labs that put cutting-edge technology for design and construction - such as 3D printers and laser cutters - into the hands of middle and high school students.

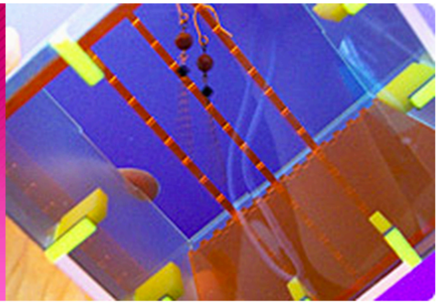
WORKSHOP @ IDC 2013

A half-day workshop on Digital Fabrication and Making in Education will take place on Monday afternoon, June 24th, 2013.

This is a satellite event of the 12th International Conference on Interaction Design and Children - IDC 2013.

Projects

Check out past student projects!



Resources

Find useful link, activities, and tutorials here!

FabLabs@School Around the World

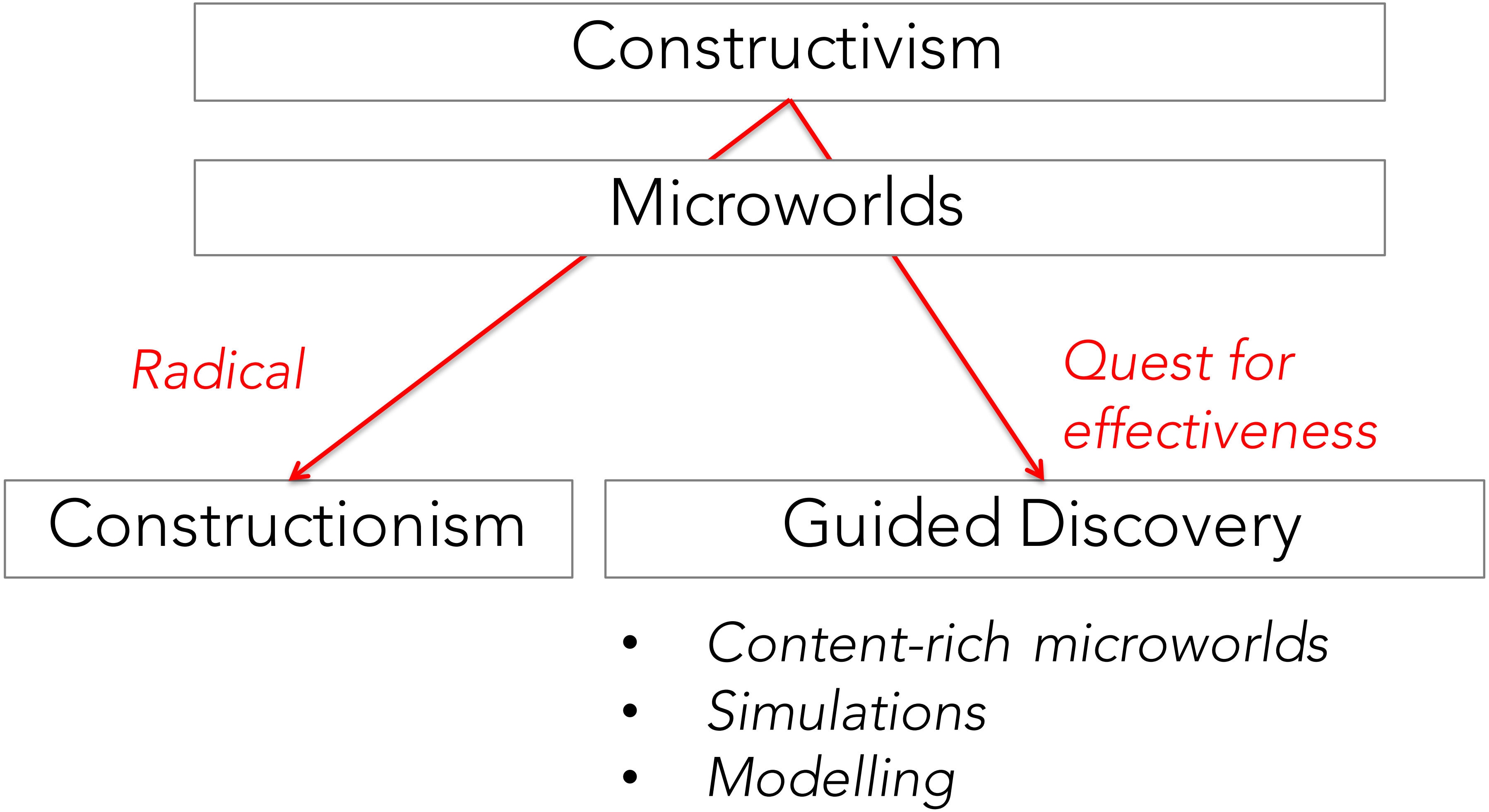
CASTILLEJA SCHOOL | RUSSIA | STANFORD | THAILAND

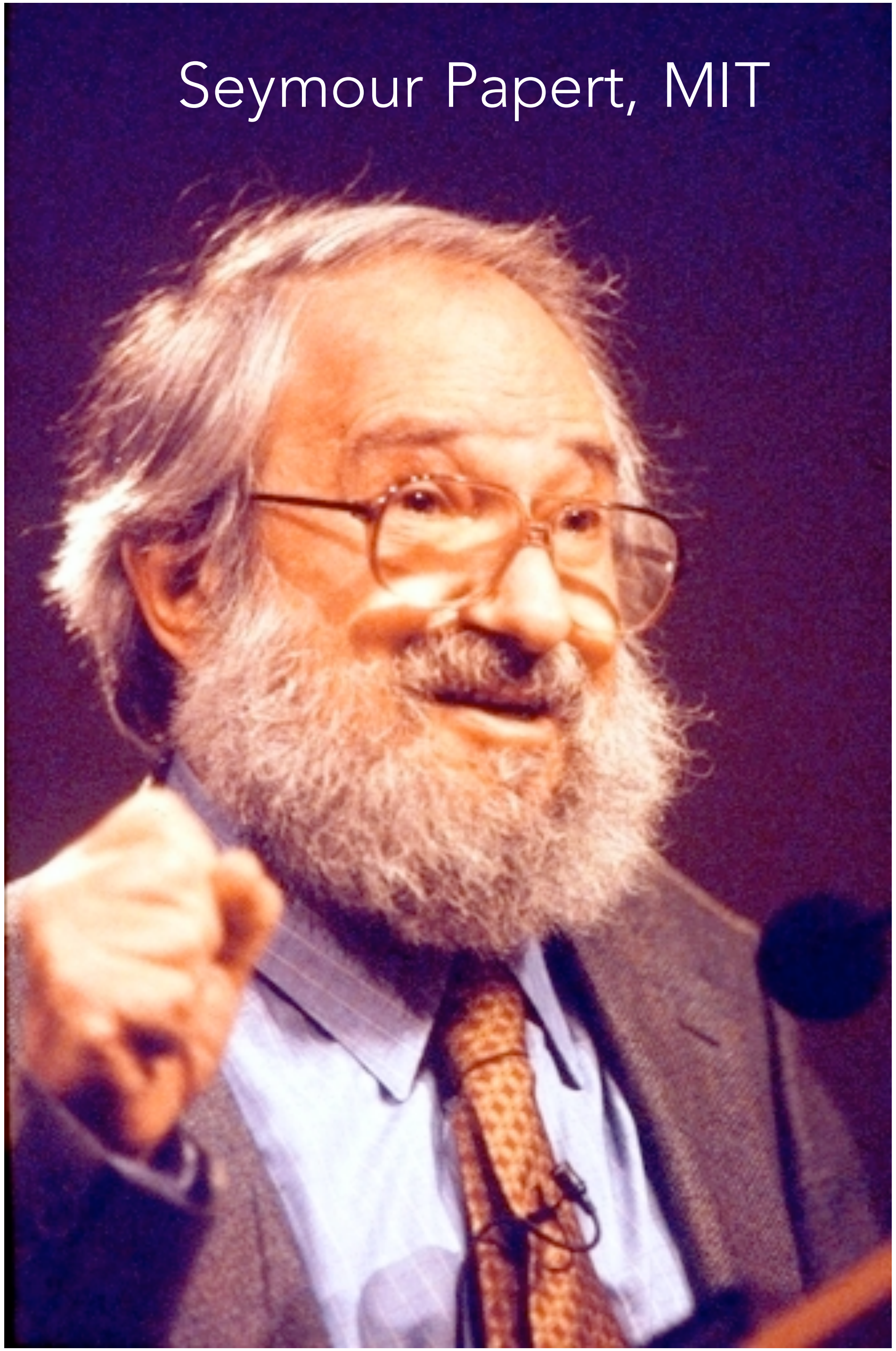
How to Get a FabLab@ School

Badges | Report an Issue | Terms of Service

http://www.3ders.org/articles/20120701-fayetteville-free-library-launched-3d-printing-fab-lab.html

From constructivism to constructionnism


Constructivism
Microworlds
Radical
Quest for effectiveness
Constructionism
Guided Discovery
• Content-rich microworlds
• Simulations
• Modelling



Seymour Papert, MIT

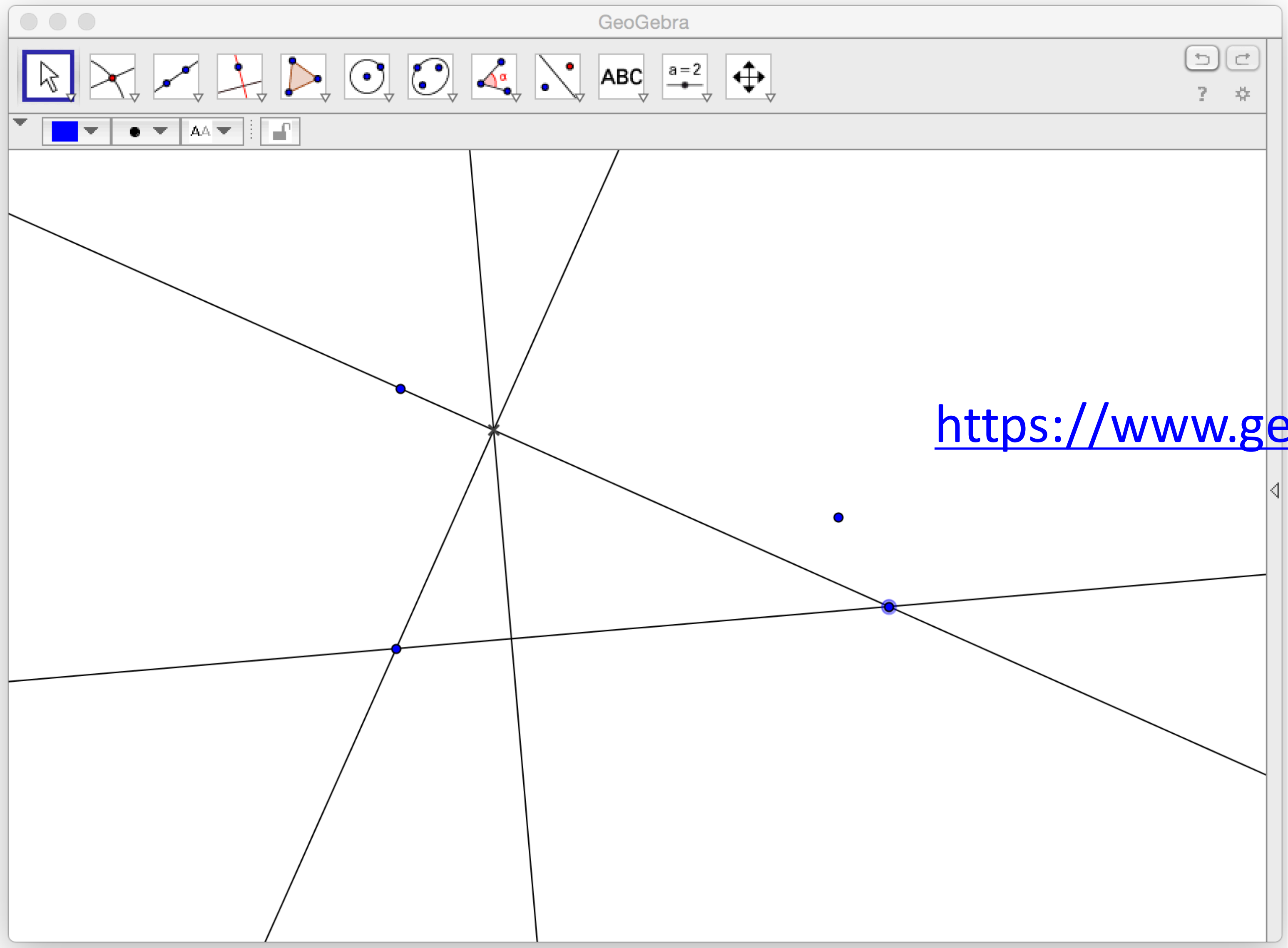
« Radical » branch

The scandal of education is that every time you teach something, you deprive a [student] of the pleasure and benefit of discovery.

I think schools generally do an effective and terribly damaging job of teaching children to be infantile, dependent, intellectually dishonest, passive and disrespectful to their own developmental capacities.

Every maker of video games knows something that the makers of curriculum don't seem to understand. You'll never see a video game being advertised as being easy. Kids who do not like school will tell you it's not because it's too hard.

Quest for effectiveness: Adding Contents

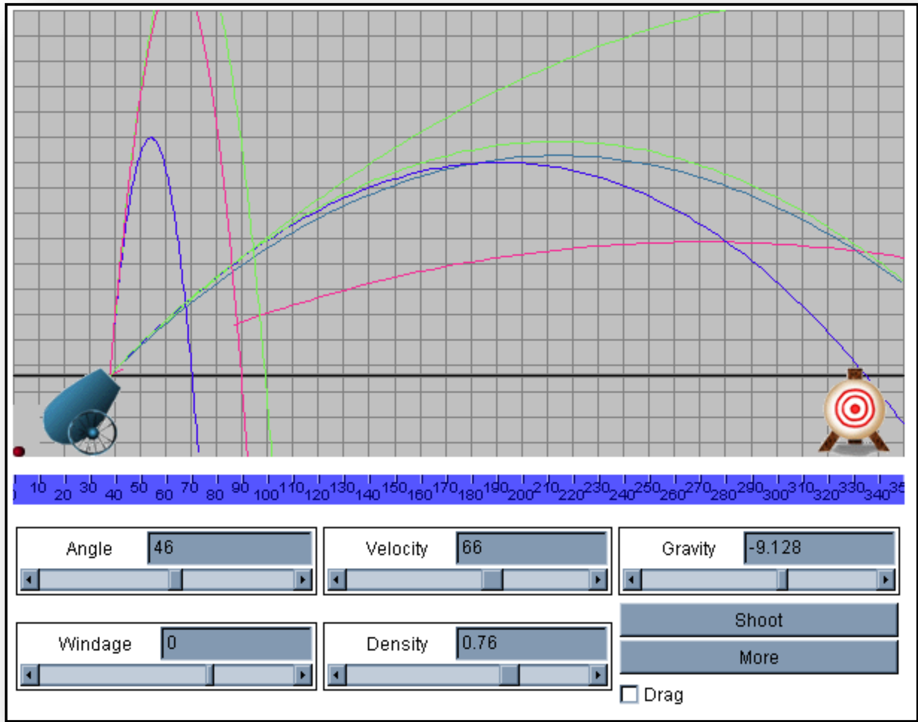


https://www.geogebra.org/

Cabri Géomètre

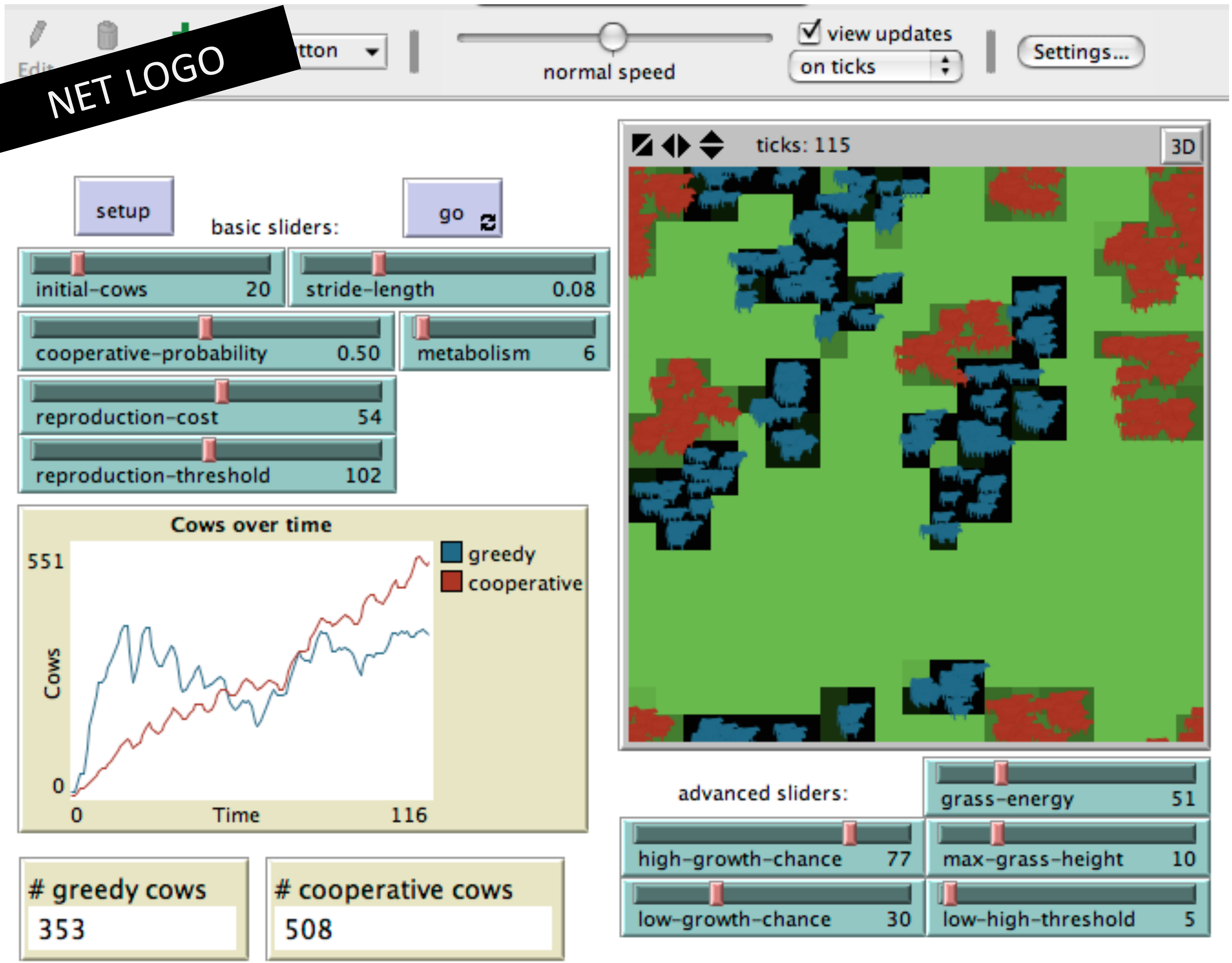
Learning from Simulations

Acquire Skills



Discover underlying model

NET LOGO



Edit
tton
normal speed
view updates
on ticks
Settings...
ticks: 115
3D
setup
basic sliders:
go
initial-cows 20
stride-length 0.08
cooperative-probability 0.50
metabolism 6
reproduction-cost 54
reproduction-threshold 102
Cows over time
551
Cows
0
0
Time
116
greedy
cooperative
greedy cows
353
cooperative cows
508
advanced sliders:
grass-energy 51
high-growth-chance 77
max-grass-height 10
low-growth-chance 30
low-high-threshold 5

Learning from Simulations

More examples

An Overview paper

Inquiry learning

"Inquiry-based learning involves learners

- asking questions about the natural or material world,
- collecting data to answer those questions,
- making discoveries and
- testing those discoveries rigorously"

de Jong, 2006

Hypothetico-deductive reasoning

1. (Raise a question)
2. Generate an hypothesis
3. Design an experiment
4. Run/simulate the experiment
5. Interpret results

But…

1. Question
2. Hypothesis
3. Design
4. Run
5. Interpret

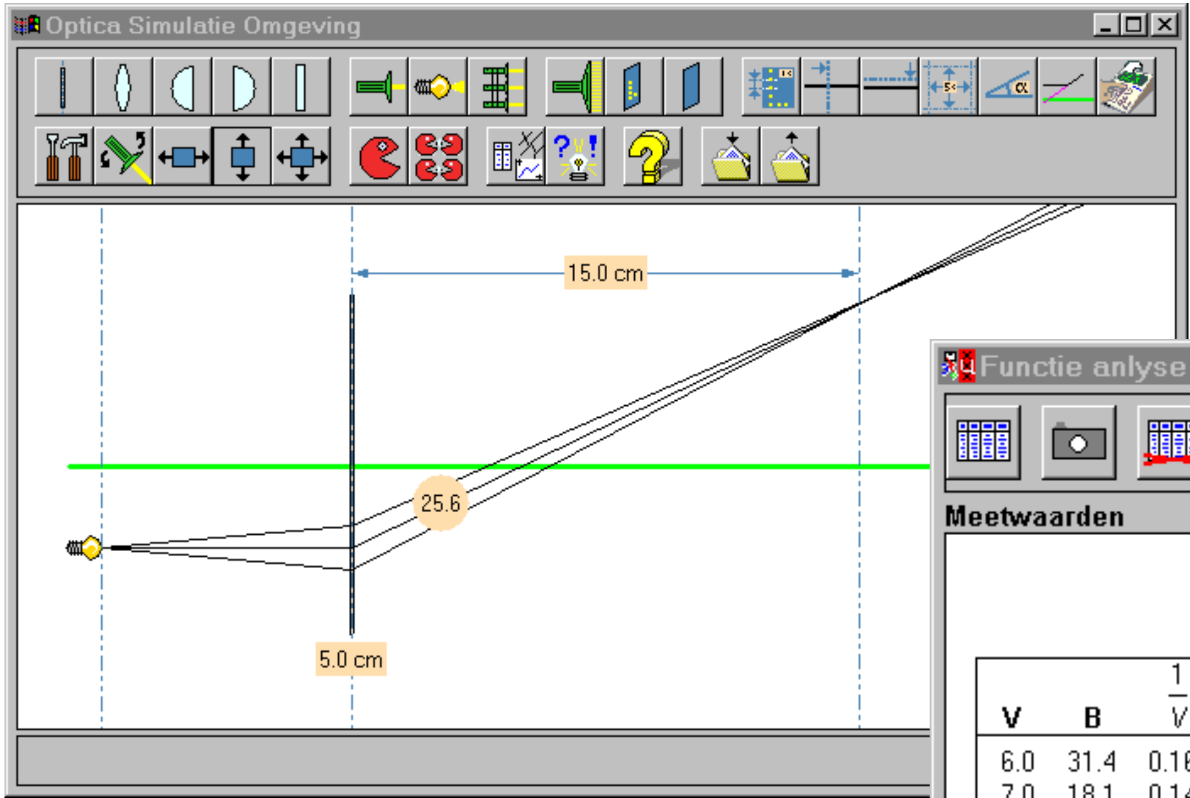
- No clear hypothesis is formulated or badly formulated (42%), i.e. no reationship between variables
- Design unconclusive experiments, students vary several parameters at at time
- Confirmation bias: to design experience that confirm the hypothesis
- 35% to 63% errors in data interpretration and graphics readings

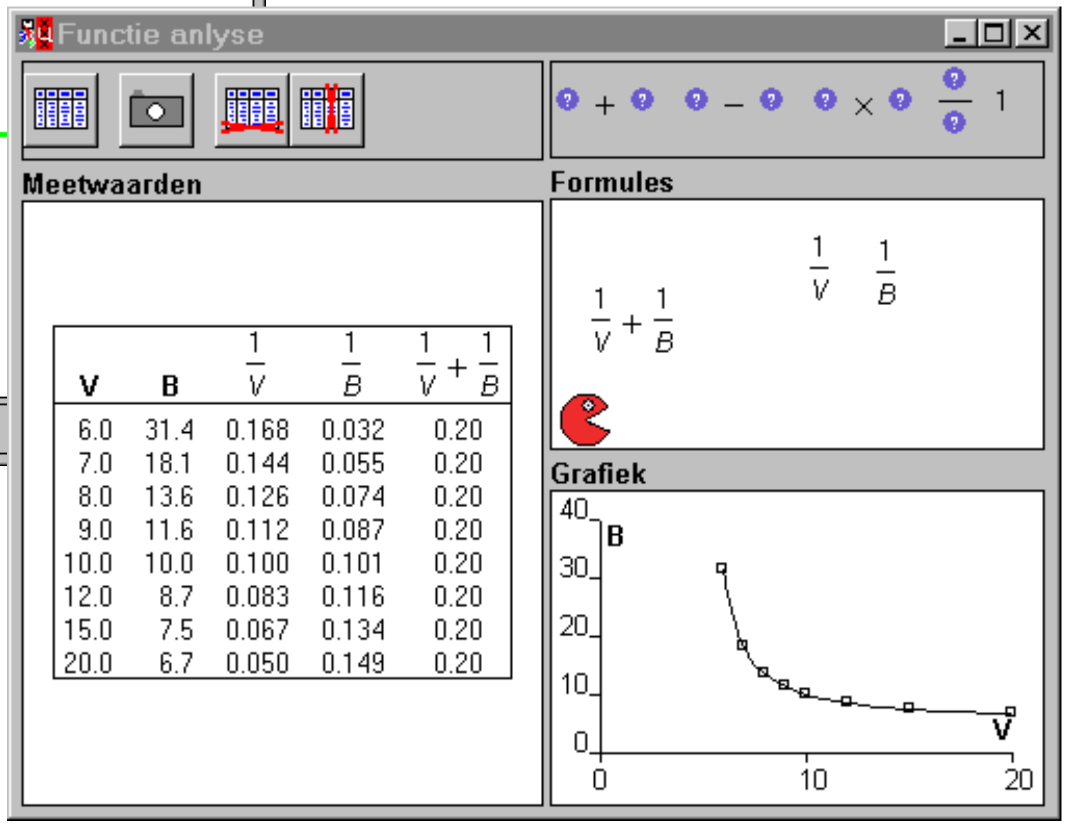
And…

1. Question
2. Hypothesis
3. Design
4. Run
5. Interpret

- Change several parameters
- Keep hypothesis despite negative evidence
- Reject hypothesis despite positive evidence

Example of tools to overcome these pitfalls





Tool to express hypotheses

Example of scenario to overcome these pitfalls

① Ask students to write their hypothesis

② Find student with conflicting hypothesis

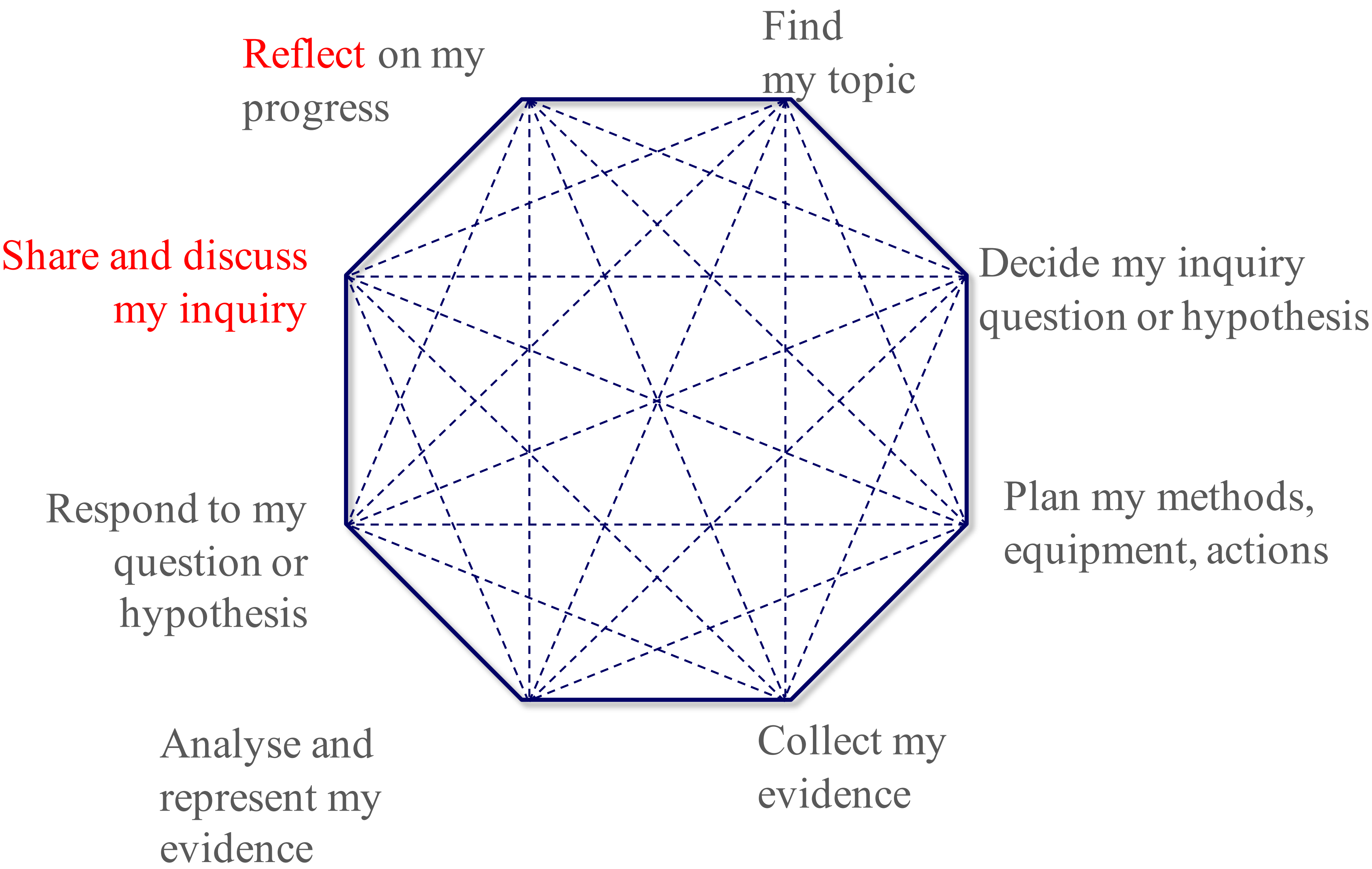
③ Ask them to find out with the simulation which hypothesis is right

Gijlers, H., & De Jong, T. (2005). The relation between prior knowledge and students' collaborative discovery learning processes. Journal of research in science teaching, 42(3), 264-282.

The effects of any learning technology depends upon the quality of classroom orchestration

Cycle of engagement and reflection

by Mike Sharples, Open Universty



Inquiry is a more open process than simulations

A lesson is not inquiry based if:

- Students know what results they are supposed to get
- The questions and steps are pre-determined for them
- The teacher is working harder than the students

http://www.stemmom.org/2012/03/what-inquiry-is-not.html

Sharples, M., Collins, T., Fei\sstM., Gaved, M., Mulholland, P., Paxton, M., & Wright, M. (2011). A Laboratory of Knowledge-Making for Personal Inquiry Learning. Artificial Intelligence in Education.

ScienceScope

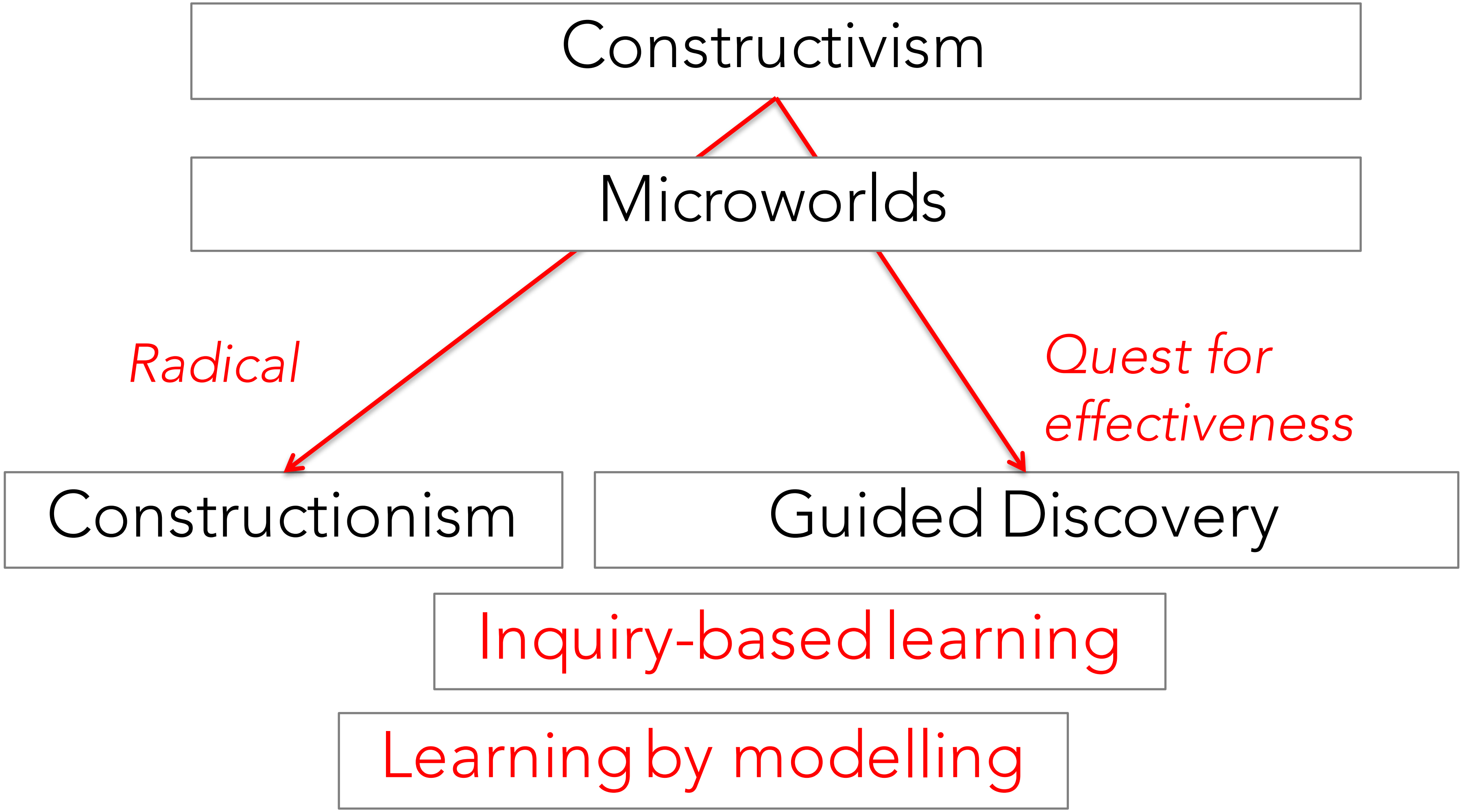
Linking ICT With Science Education

http://www.sciencescope.co.uk/Pages/SensorCategories.aspx

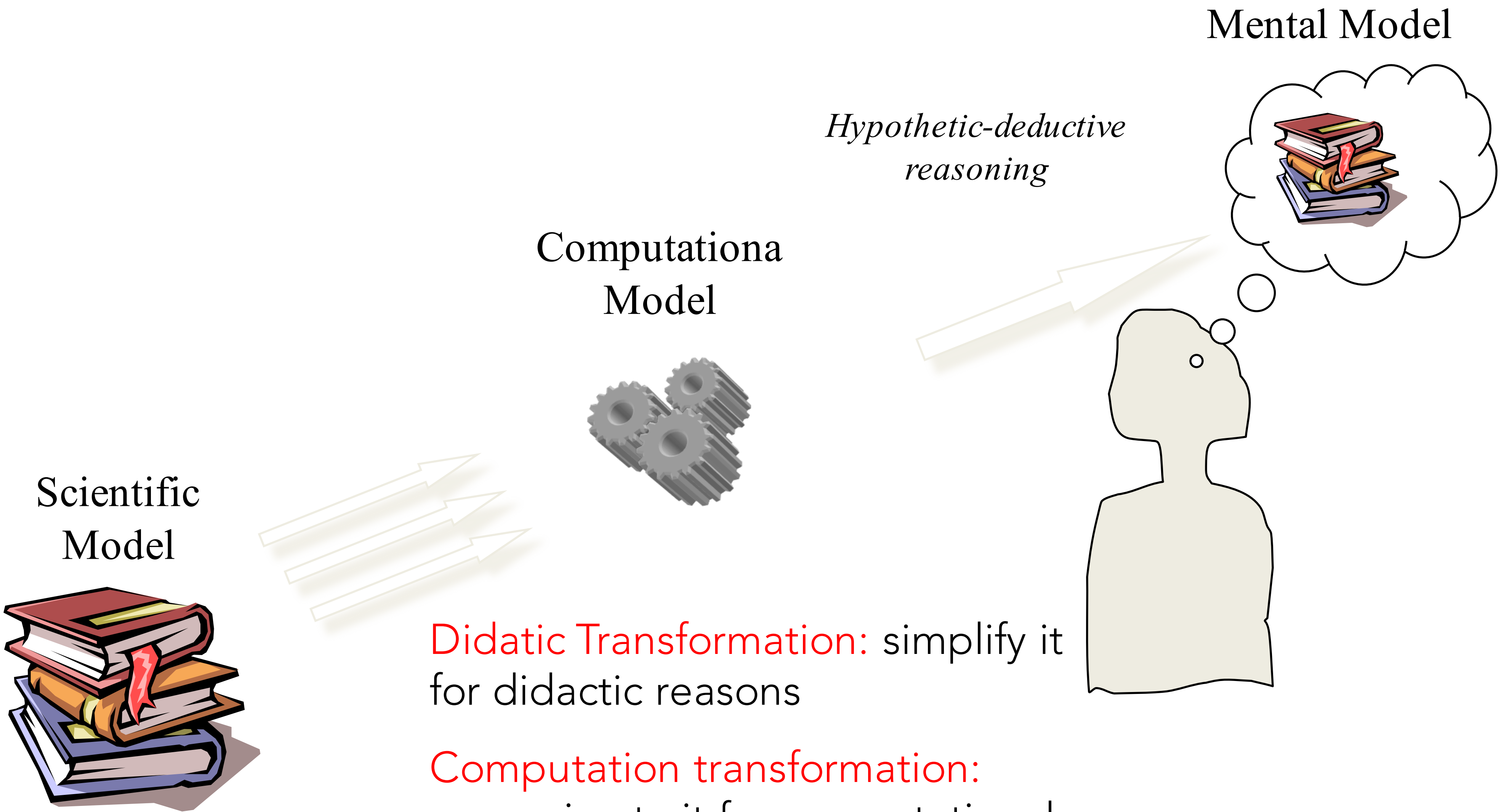
Sensors

- 3 cm Wave Signal Strength
- AC MilliVolt
- Accelerometer 2 axis
- Accelerometer 3 axis
- Altimeter
- Anemometer
- Carbon Dioxide
- Carbon Dioxide Replacement Cell
- Carbon Monoxide
- Carbon Monoxide Replacement Cell
- Charge Sensor
- Conductivity
- Current ±1 A
- Current ±1 mA
- Current ±10 A
- Current ±100 mA
- Distance IR
- Distance Ultrasonic Basic
- Electrosmog advanced
- Electrosmog Basic
- Flow Advanced
- Flow Meter
- Force Dual Range
- Frequency
- Humidity
- IR Irradiance
- Joulemeter
- Light (Advanced)
- Light (General Purpose)
- Magnetic Field with 100mT Probe
- Magnetic Probe 30 mT
- Nitrogen Dioxide
- Oxygen Atmospheric
- Oxygen Atmospheric Cell
- Oxygen Probe - Dissolved
- pH Interface
- pH Probe Sensor - advanced
- pH Probe Sensor - basic
- Pressure (Absolute 0 - 700 Kpa)
- Pressure (Absolute 0 - 200 KPa)

1 2


Constructivism
Microworlds
Radical
Quest for effectiveness
Constructionism
Guided Discovery
Inquiry-based learning
Learning by modelling

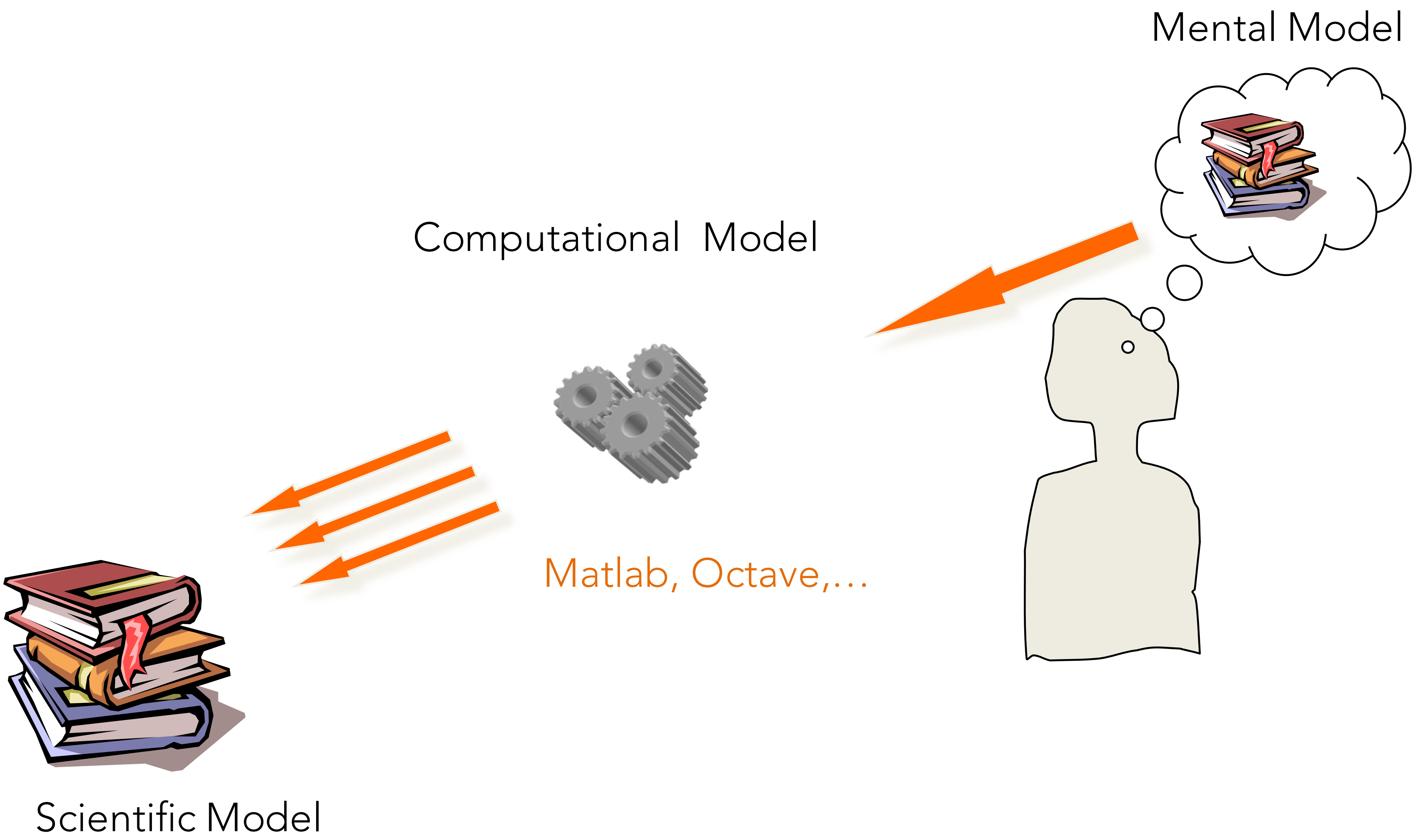
Learning from simulations



Didatic Transformation: simplify it for didactic reasons

Computation transformation: approximate it for computational reasons

Learning from modelling



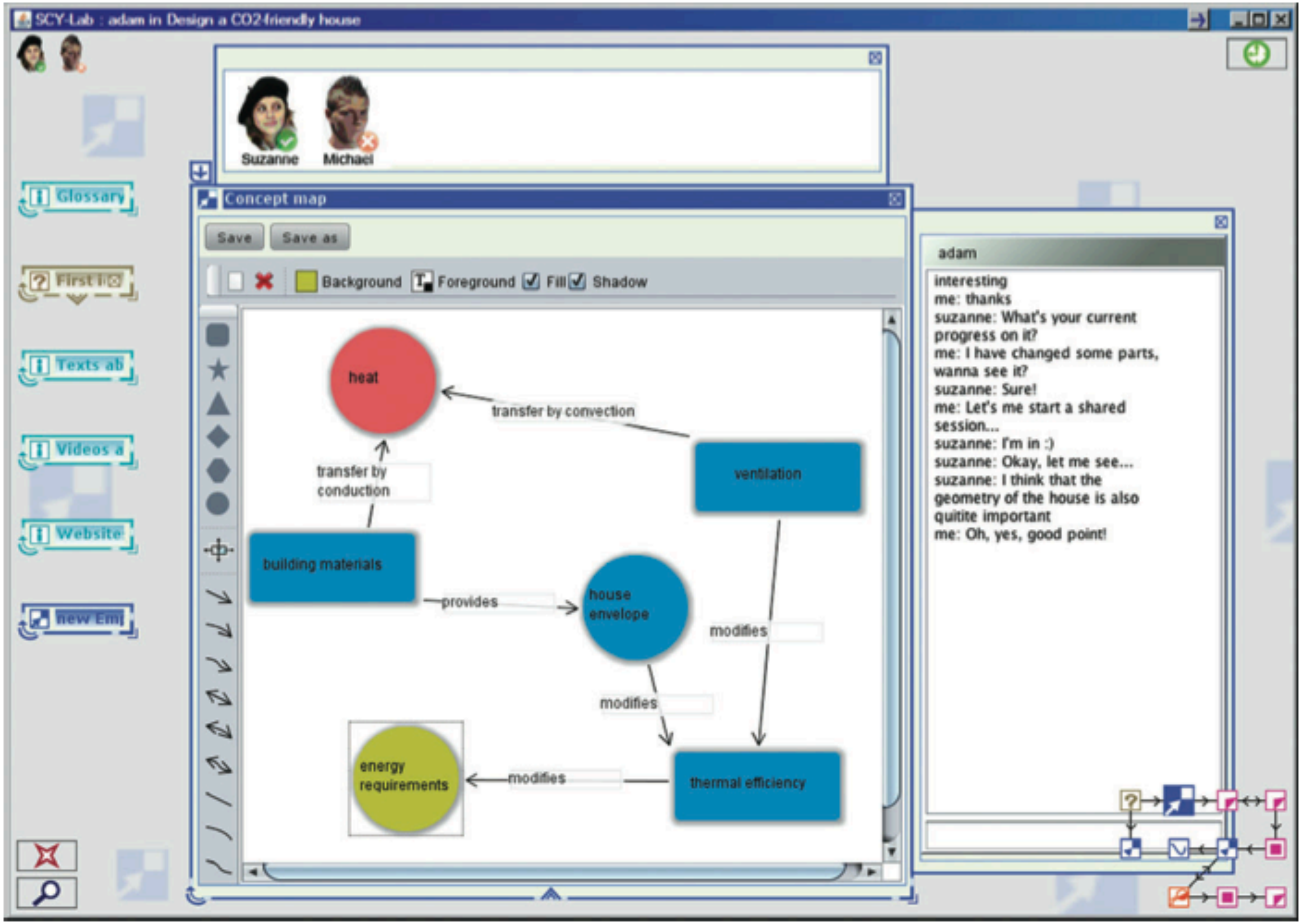
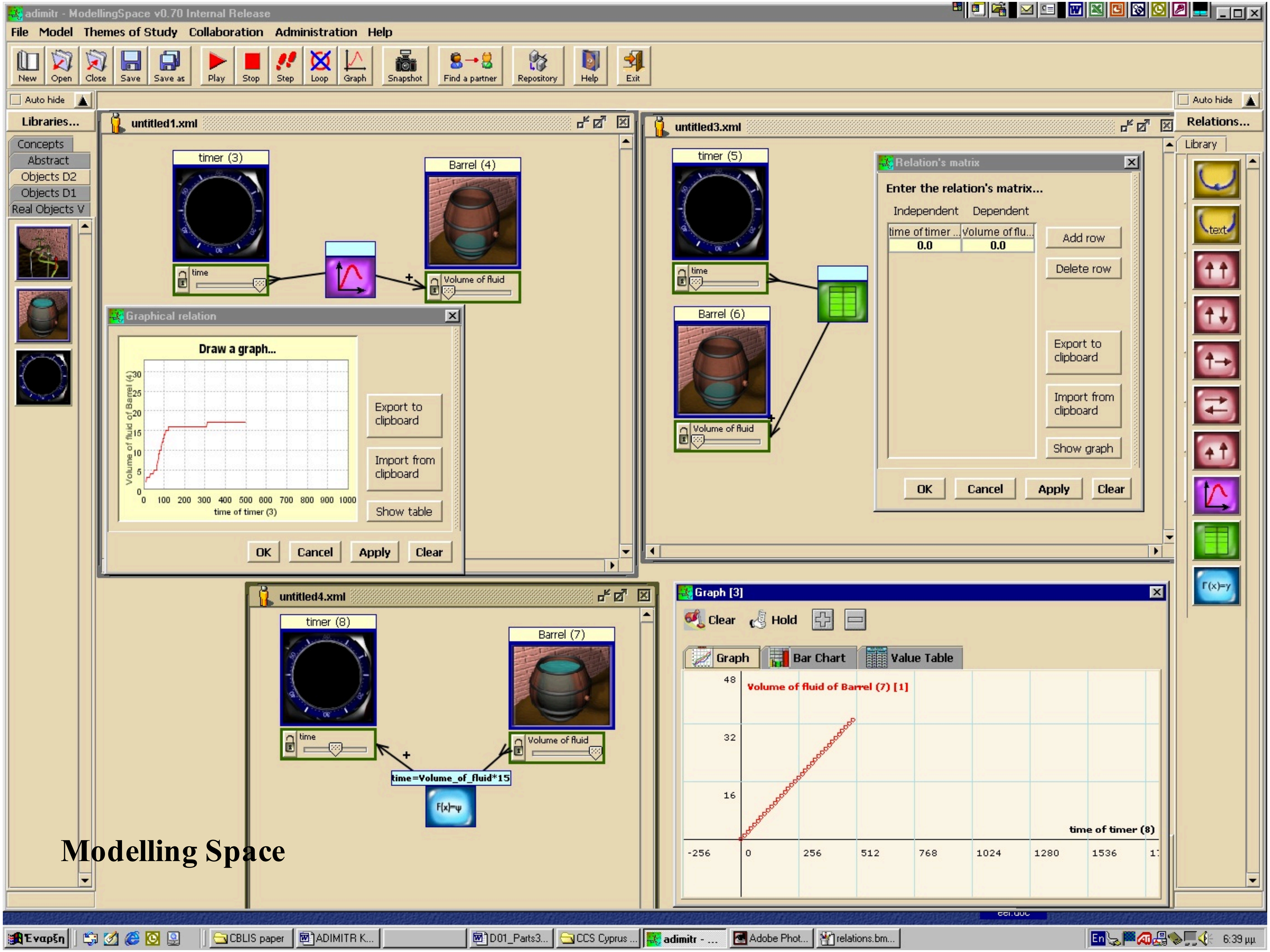
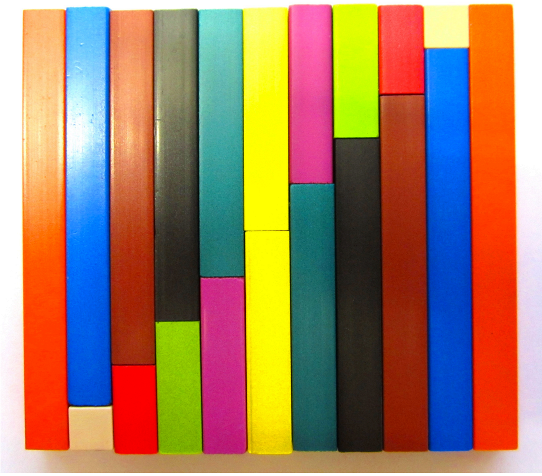


Figure 2: A SCY concept map with drawers attached. Available peers are above and a SCYchat is active to the right

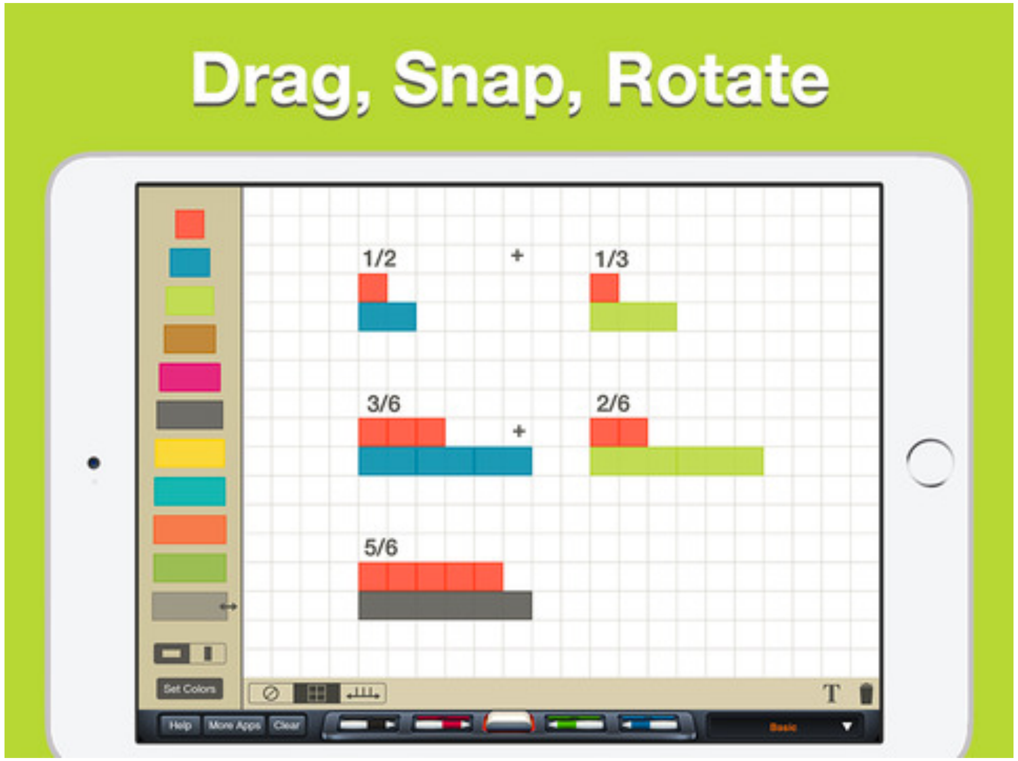


Modelling Space

Manipulating real or virtual objects ?



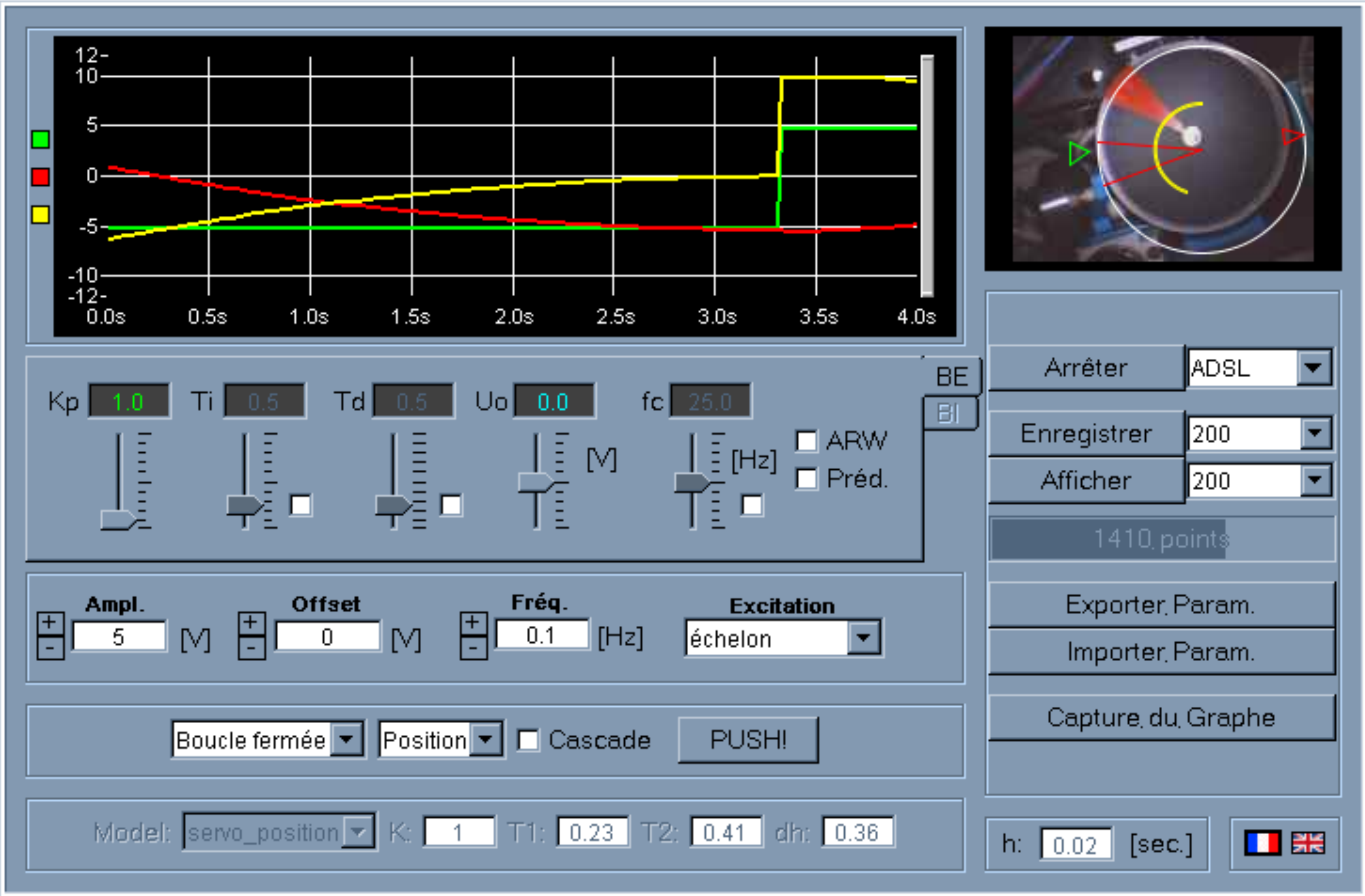
Cuisenaire Rods



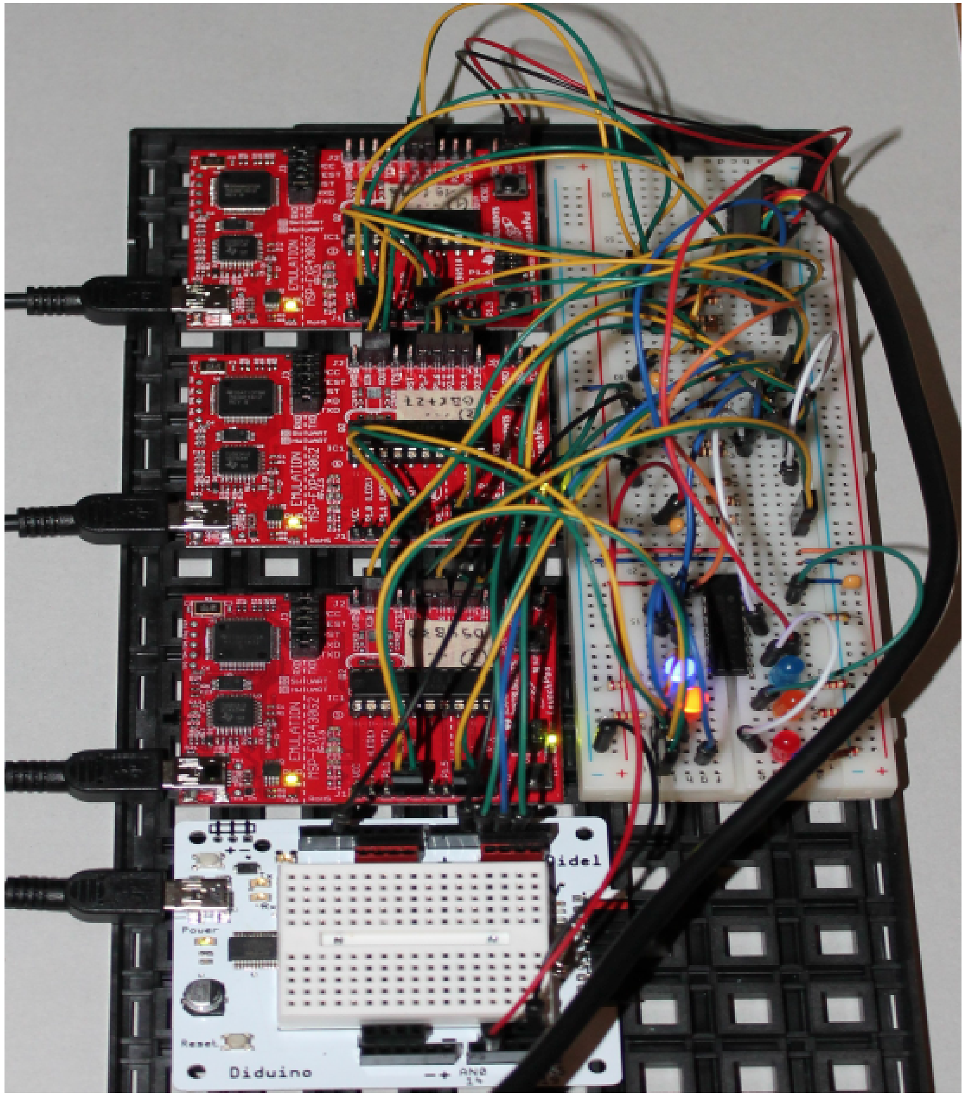
iPad Version

https://itunes.apple.com/gb/app/number-rods/id536204074?mt=8

The real-virtual debate: offer both!



http://emersion.epfl.ch/mechatronics/index.html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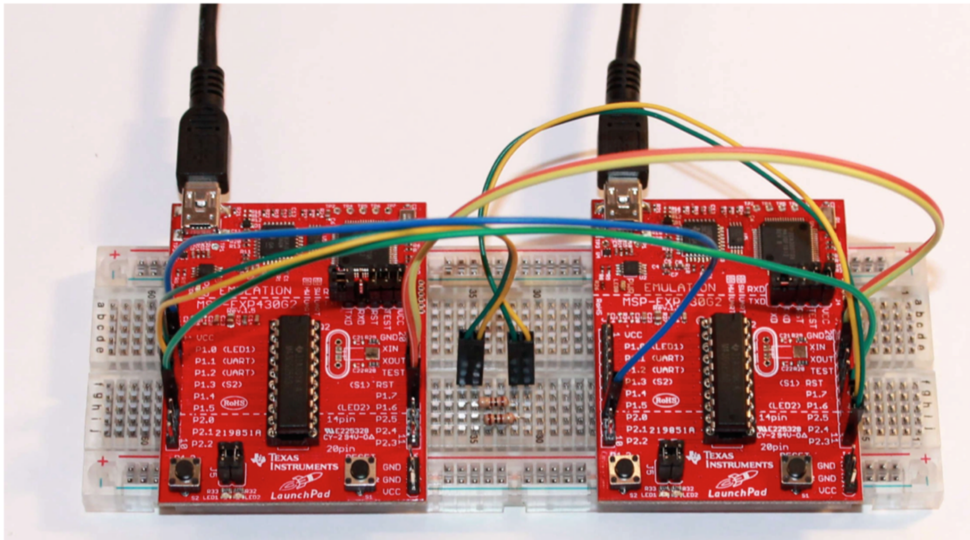
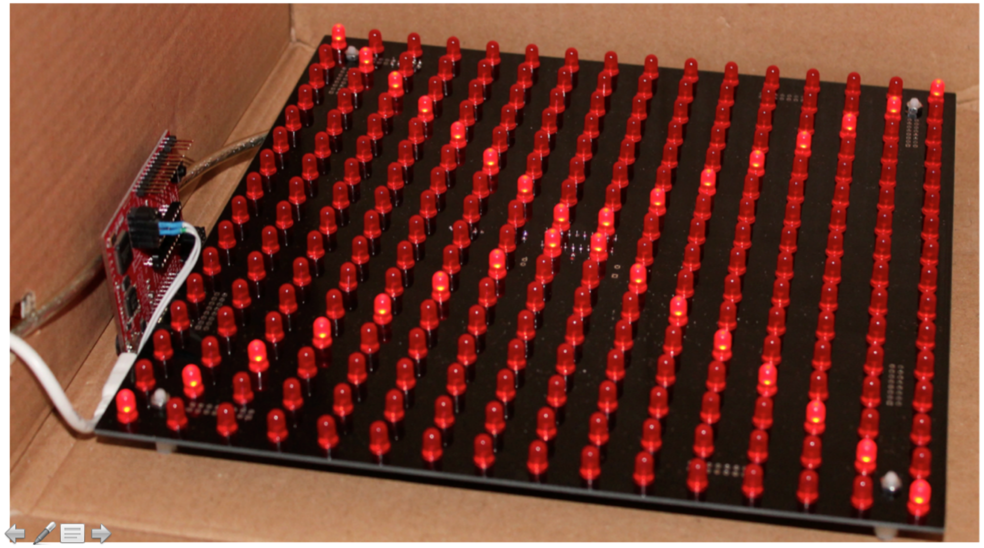
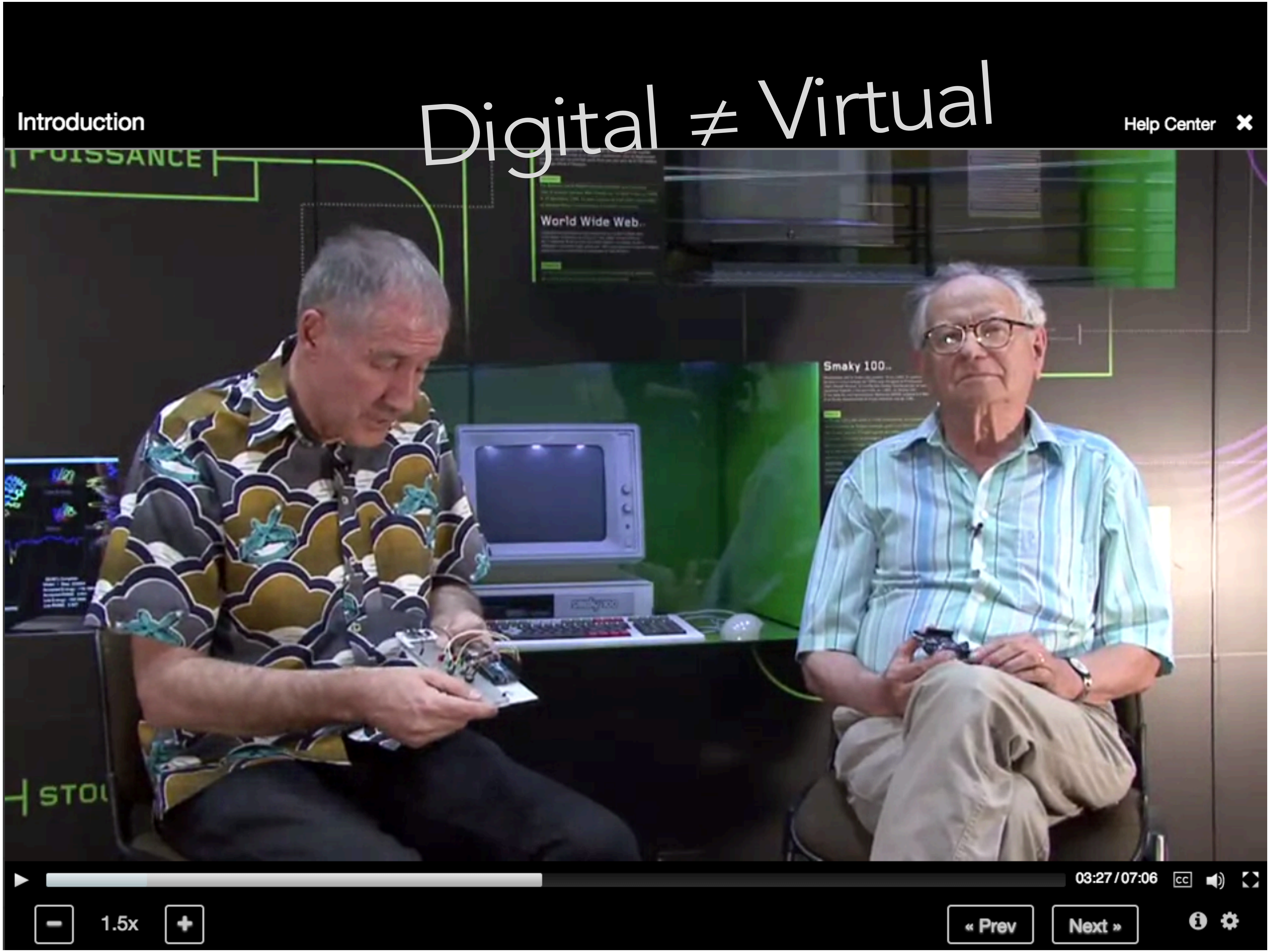
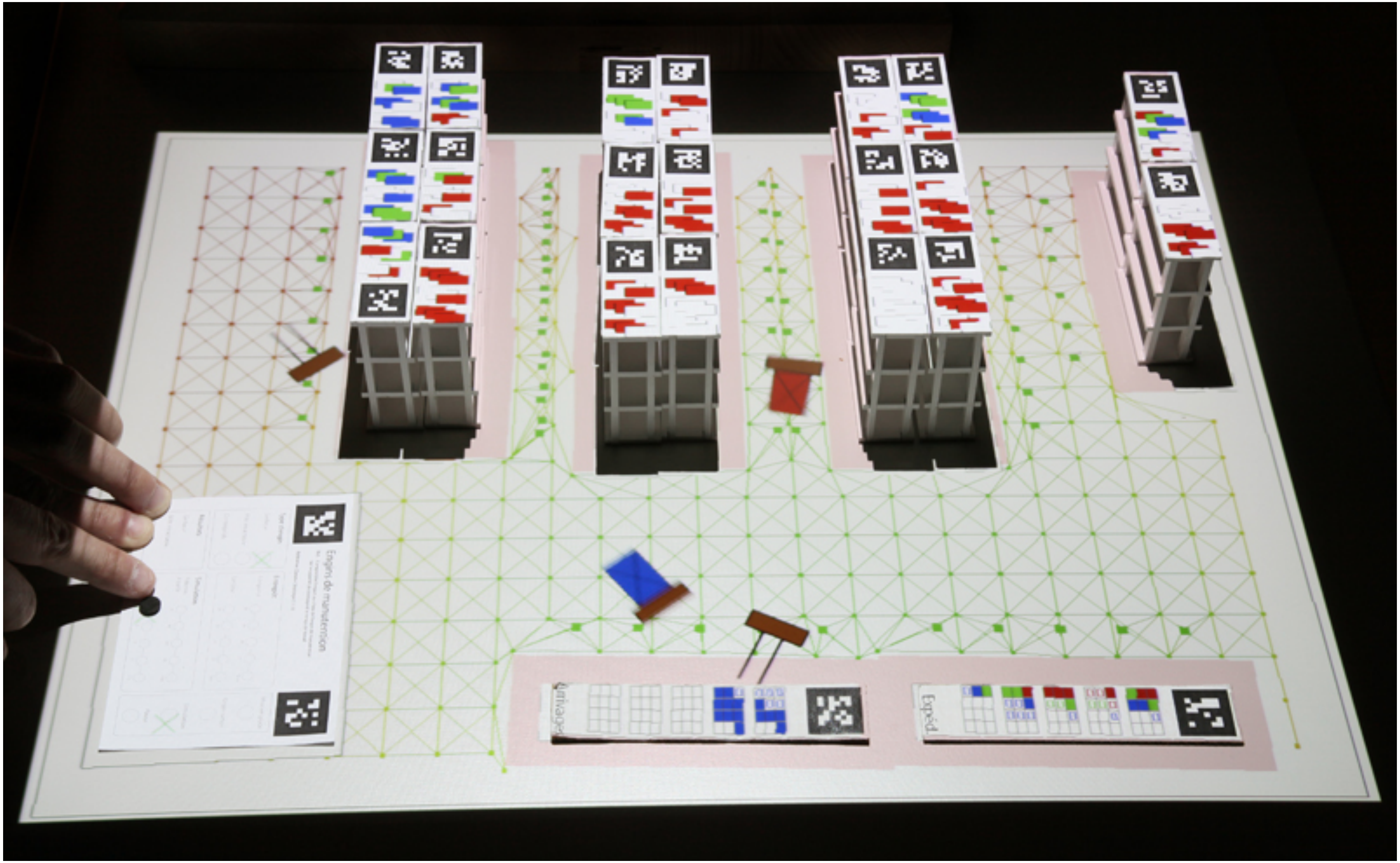



Digital ≠ Virtual

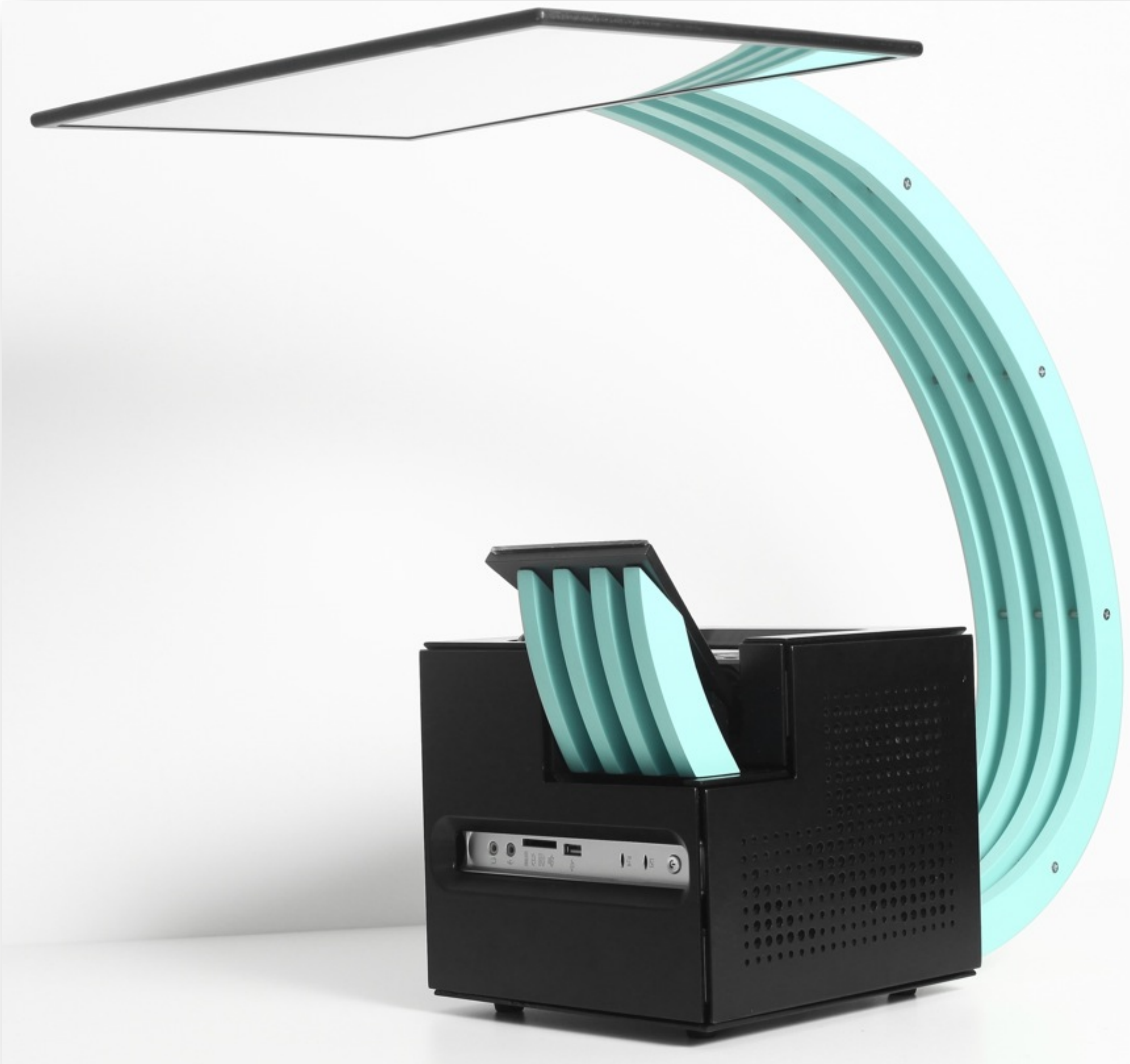


Manipulating real or virtual objects ?



Logistics Apprentzices


KOSMOS
Elektro-Krokodil
Roboter Käfer
KOSMOS
KAEFER-ROBOTER
ART. NR. 658014
INHALT: 5 STK.
MADE IN CHINA



Simpliquity

Summary:
From Constructivism to Augmented Reality

1. People don't learn by being taught but by adapting their knowledge structures through interaction with artefacts. Educational philosophy: from telling students what to do to letting them invent things

2. In practice, this approach does not work very well without external support and requires talented teachers. Learning from simulation requires inquiry skills. Training these transversal skills are key goals of any education

3. Evolution of pedagogical methods from building mental schemes to building concrete objects. Digital artefacts offer rich interactions but digital education is not limited to virtual object. Tangible interfaces and augmented reality open it to physical manipulation.