Using Technology to Didactically Challenge intuitions for STEM

Chronis Kynigos

Educational Technology Lab
University of Athens
http://etl.ppp.uoa.gr

Educational Technology Lab

Infusing Constructionism in Educational Design and Practice

- R&D projects
  - C Cube, SEED, Kaleidoscope TELMA, ESCALATE, ReMath, Metafora, M C Squared
- Technologies
  - E-slate Turtleworlds, MaLT, Cruislet , Polymechanon
- Participation in Large scale initiatives
  - Teacher education (650 T. educators, 14000 Teachers)
  - Digital School, 200 micro-experiments per school year for primary and secondary
- Design Research
  - Scenarios, digital artifacts
  - Classroom research and teacher education

Technologies

- **Digital School - Mathematics**
  - 1730 microexperiments (interactive books and photodendro portal)
- **Polymechanon**
  - 11 serious games in robotics and kinesthetic control
- **E-slate Kits** (simulations, data handling and GIS)
  - Turtleworlds
  - Dynastage
  - Sus-x
  - My Story
  - MaRs (Mathematical Relations)
- **Machinelab** (3D games and sims)
  - MaLT (3D Turtleworlds)
  - 3D simulations
- **Cruislet** (Navigational Mathematics and Geospatial data)

Projects

- **SEED**: teachers as designers
- **Kaleidoscope**: Integrations to explore the future of learning with DT
- **ReMath:** x-experimentations for integrtation
- **Escalate:** Metafora: argumentation, collaboration and planning in constructionist environments
- **Mathematical creativity squared:** social creativity to design with a c-book
- **Large scale infrastructures:** teacher education and digital school portals

Questioning intuitions

- Intuitions, p-prims and prioritizations: cuing/reliability (di Sessa)
- Intuitions are naïve experiential explanations based on phenomena
- Questioning intuitions – challenge, persistence, ‘fade-out’ so that expert explanations emerge

About Intuitions

‘although effective at all stages and remaining fundamental from the point of view of invention, the cognitive role of intuition diminishes during development. … formalization … progressively limits the field of intuition (Beth and Piaget, 1966, p. 255)

Simulations to question intuitions

- Bring the invisible to our senses through representations
- Variety of cases and embodiments to enhance actual experience
- Provide dynamic measurements and a sense of control over evolution of phenomena in time
- Operate as objects for scientific experimentation, inquiry and identification of rules/questions in seemingly complex phenomena

What are simulations designed to represent?

- A real world phenomenon?
- A virtual world phenomenon?
- An ‘engineering’ phenomenon (the behavior of an artifact or a machine)

Constructionism: Papert's original concerns

- To draw attention to epistemology
- To address the generation of meanings
- To appreciate the value of engagement, exposure, bricolage/tinkering, ownership, discourse and language
- To consider the value of computer feedback, metaphors, connected representations, extensibility, structure, expressive rigor of a programming/mathematical language
- To design in terms of creating environments rich in opportunities for meaning
- To challenge institutional perspectives

Constructionism as a learning theory

- Constructionism = dis-equilibration, rich-dense learning environment
- Generation of meanings – meanings in use
- Mathematization – seeing and generating the mathematical
- Situated abstractions – abstractions in use
- Meaningful formalism – interdependently integrated with other representations

- Can constructionist environments provide a frame to engage in the questioning of intuitions

Constructionist media

- A digital artifact as an expressive medium for students
- An artifact as a malleable object
- Artifact as an improvable boundary object
- Explicitness in what is changed by who and what meaning the change carries
- Design for teachers, students

Constructionism and the design of questionable simulations

- Half-baked microworlds – malleable and questionable curriculum
- Boundary objects – improvable-questionable digital artifacts in collective learning situations
- Black and white box designs
- Deep structural access
- Interplay between private and public expression
- Rethinking content, structure and epistemology

Half baked microworlds: artifacts questionable by design

- Digital artifacts which are by design
  - Malleable
  - Questionable
  - Faulty
  - Improvable
- Making changes is an integral part of expressing mathematical meanings
- They are meant to take the role of boundary objects
- They help create structured agendas for mathematical discussion

Questionable simulations

- To question the validity of a representation
- To question the behaviors, object relations and field properties
- To change simulation rules
- To engage in experimentation
- To challenge intuitions about phenomena
  - To explain a phenomenon
  - To explain an engineered phenomenon

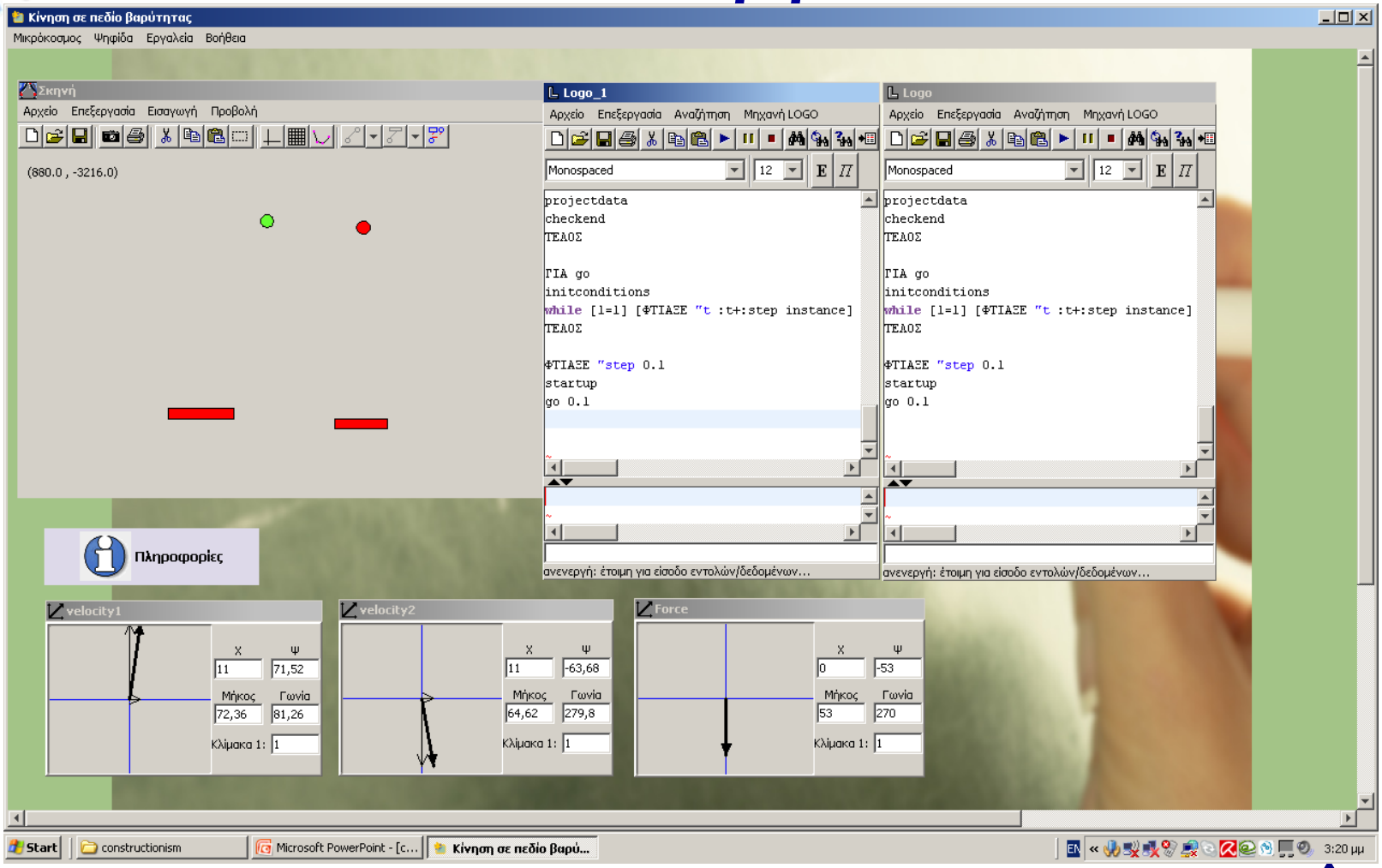
Emergent themes

- Shifting across conceptual fields
- Challenging intuitions about physical phenomena to explain engineered behaviors
- What does the simulation represent
- Does it represent a phenomenon correctly?

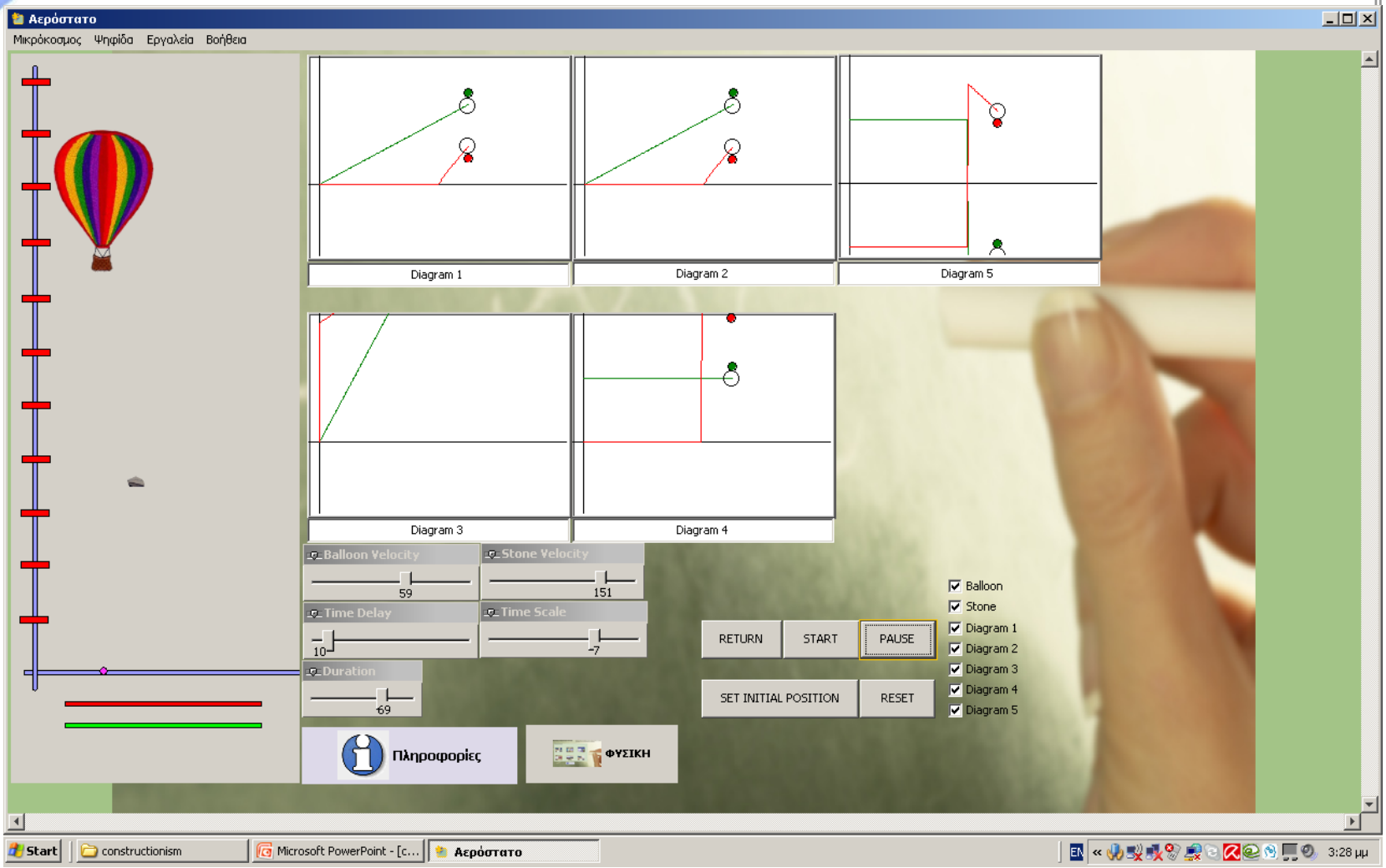
Intuitions: Example n1

- Newtonian trajectories (velocity – gravity) and collisions

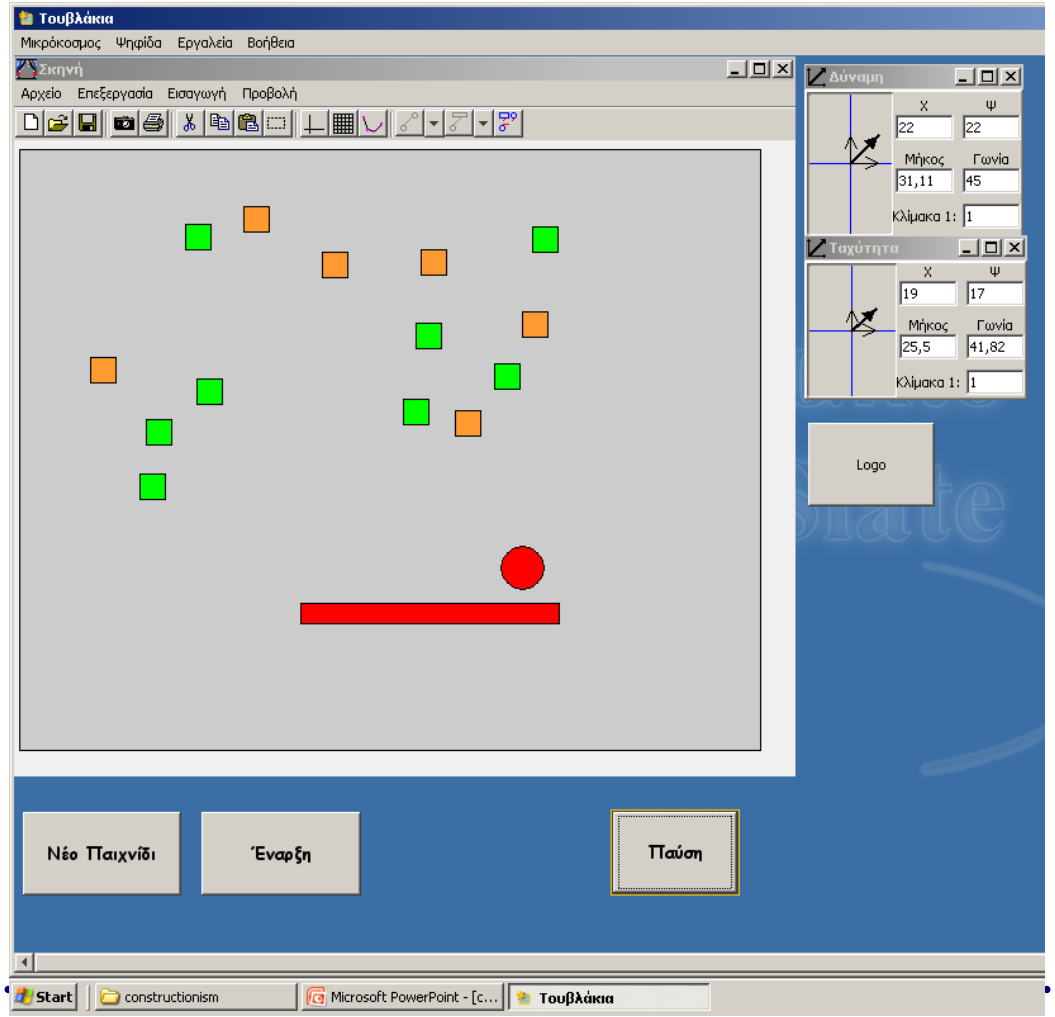
Juggler


Κίνηση σε πεδίο βαρύτητας
Μικρόκοσμος Ψηφίδα Εργαλεία Βοήθεια
Σκηνή
Αρχείο Επεξεργασία Εισαγωγή Προβολή
(880.0 , -3216.0)
Logo_1
Αρχείο Επεξεργασία Αναζήτηση Μηχανή LOGO
Monospaced
12
projectdata
checkend
ΤΕΛΟΣ
ΓΙΑ go
initconditions
while [1=1] [ΦΤΙΑΞΕ "t :t+:step instance]
ΤΕΛΟΣ
ΦΤΙΑΞΕ "step 0.1
startup
go 0.1
ανενεργή: έτοιμη για είσοδο εντολών/δεδομένων...
Logo
Αρχείο Επεξεργασία Αναζήτηση Μηχανή LOGO
Monospaced
12
projectdata
checkend
ΤΕΛΟΣ
ΓΙΑ go
initconditions
while [1=1] [ΦΤΙΑΞΕ "t :t+:step instance]
ΤΕΛΟΣ
ΦΤΙΑΞΕ "step 0.1
startup
go 0.1
ανενεργή: έτοιμη για είσοδο εντολών/δεδομένων...
Πληροφορίες
velocity1
X Ψ
11 71,52
Μήκος Γωνία
72,36 81,26
Κλίμακα 1: 1
velocity2
X Ψ
11 -63,68
Μήκος Γωνία
64,62 279,8
Κλίμακα 1: 1
Force
X Ψ
0 -53
Μήκος Γωνία
53 270
Κλίμακα 1: 1
Start
constructionism
Microsoft PowerPoint - [c...
Κίνηση σε πεδίο βαρύ...
3:20 μμ

Balloon


Αερόστατο
Μικρόκοσμος Ψηφίδα Εργαλεία Βοήθεια
Diagram 1
Diagram 2
Diagram 5
Diagram 3
Diagram 4
Balloon Velocity
59
Stone Velocity
151
Time Delay
10
Time Scale
-7
Duration
69
RETURN
START
PAUSE
SET INITIAL POSITION
RESET
Balloon
Stone
Diagram 1
Diagram 2
Diagram 3
Diagram 4
Diagram 5
Πληροφορίες
ΦΥΣΙΚΗ
Start
constructionism
Microsoft PowerPoint - [c...
Αερόστατο
3:28 μμ

Arcanoid


Τουβλάκια
Μικρόκοσμος Ψηφίδα Εργαλεία Βοήθεια
Σκηνή
Αρχείο Επεξεργασία Εισαγωγή Προβολή
Δύναμη
X Ψ
22 22
Μήκος Γωνία
31,11 45
Κλίμακα 1: 1
Ταχύτητα
X Ψ
19 17
Μήκος Γωνία
25,5 41,82
Κλίμακα 1: 1
Logo
Νέο Παιχνίδι
Έναρξη
Παύση
Start
constructionism
Microsoft PowerPoint - [c...
Τουβλάκια

Intuitions: Example n2

- Physical vs virtual collisions and friction

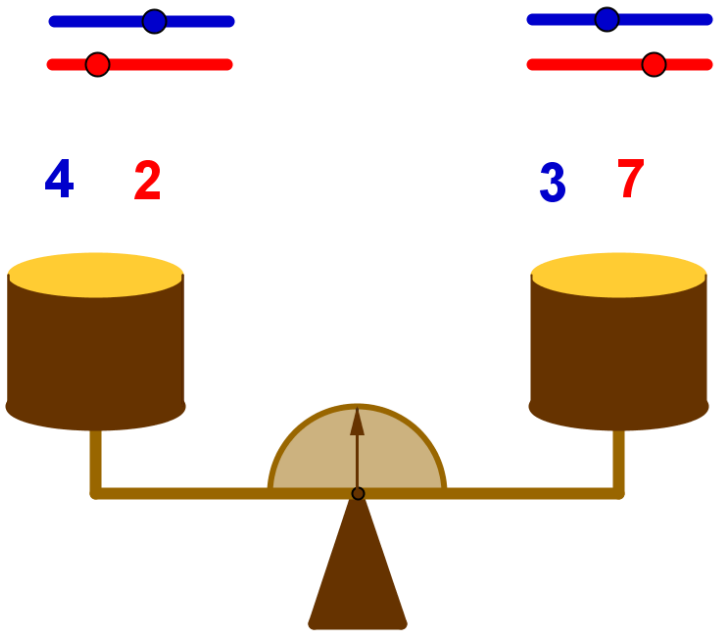
SCORE 00

SCORE 01
01:55

Intuitions: Example n. 3

- Mathematical equality vs balancing of a scale

Scales for maths



The scales you see have two pots
which we can fill with blue balls
and red balls.

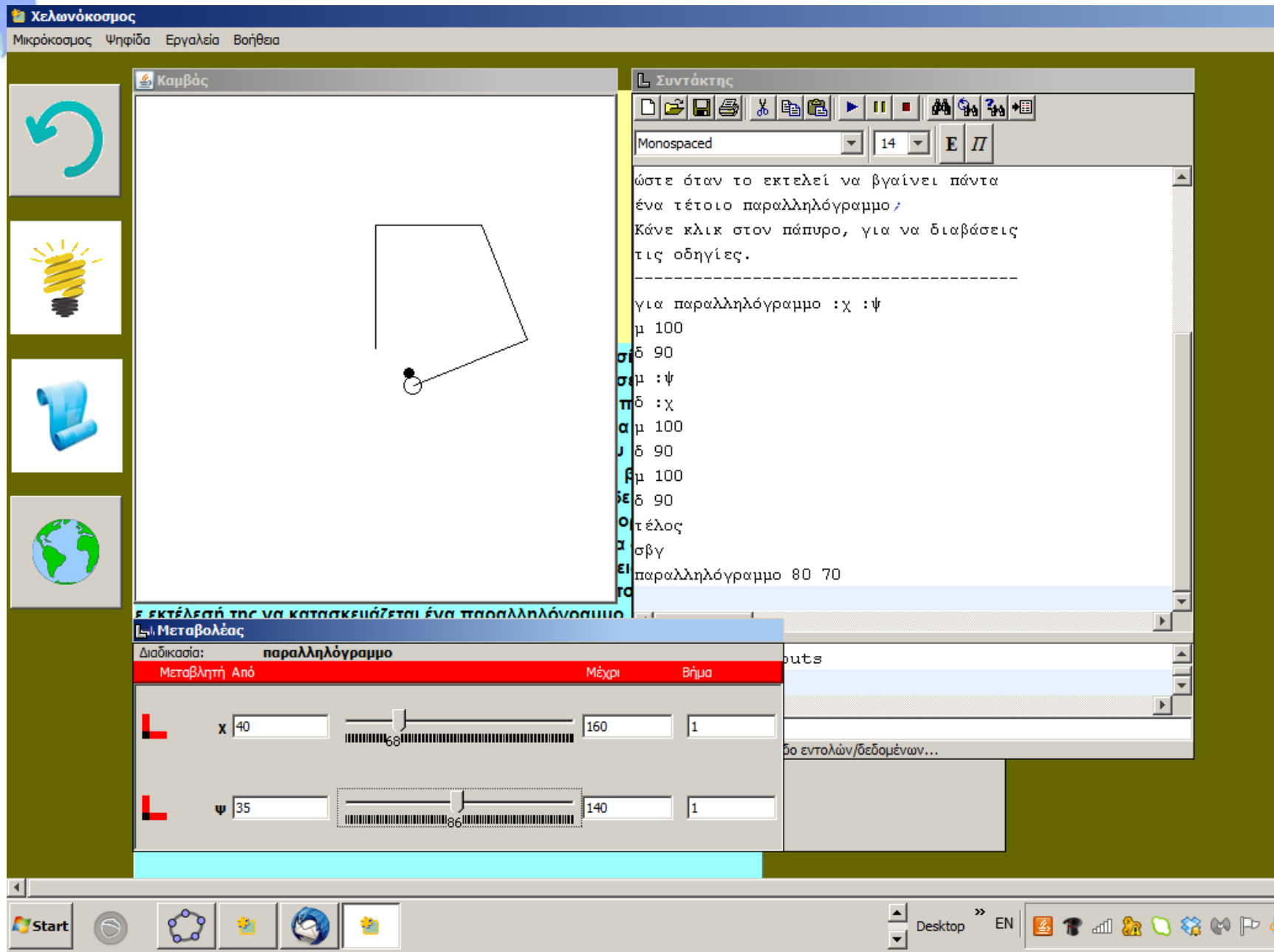
The red balls weigh 20 grams each.
Is there any chance the scales are faulty?

1. Move the +/- dots on the blue or red slider
to add or take away blue or red balls from the respective pot.
2. The numbers on top of each pot show how many balls it contains.

Can you work out how much each blue ball weighs?

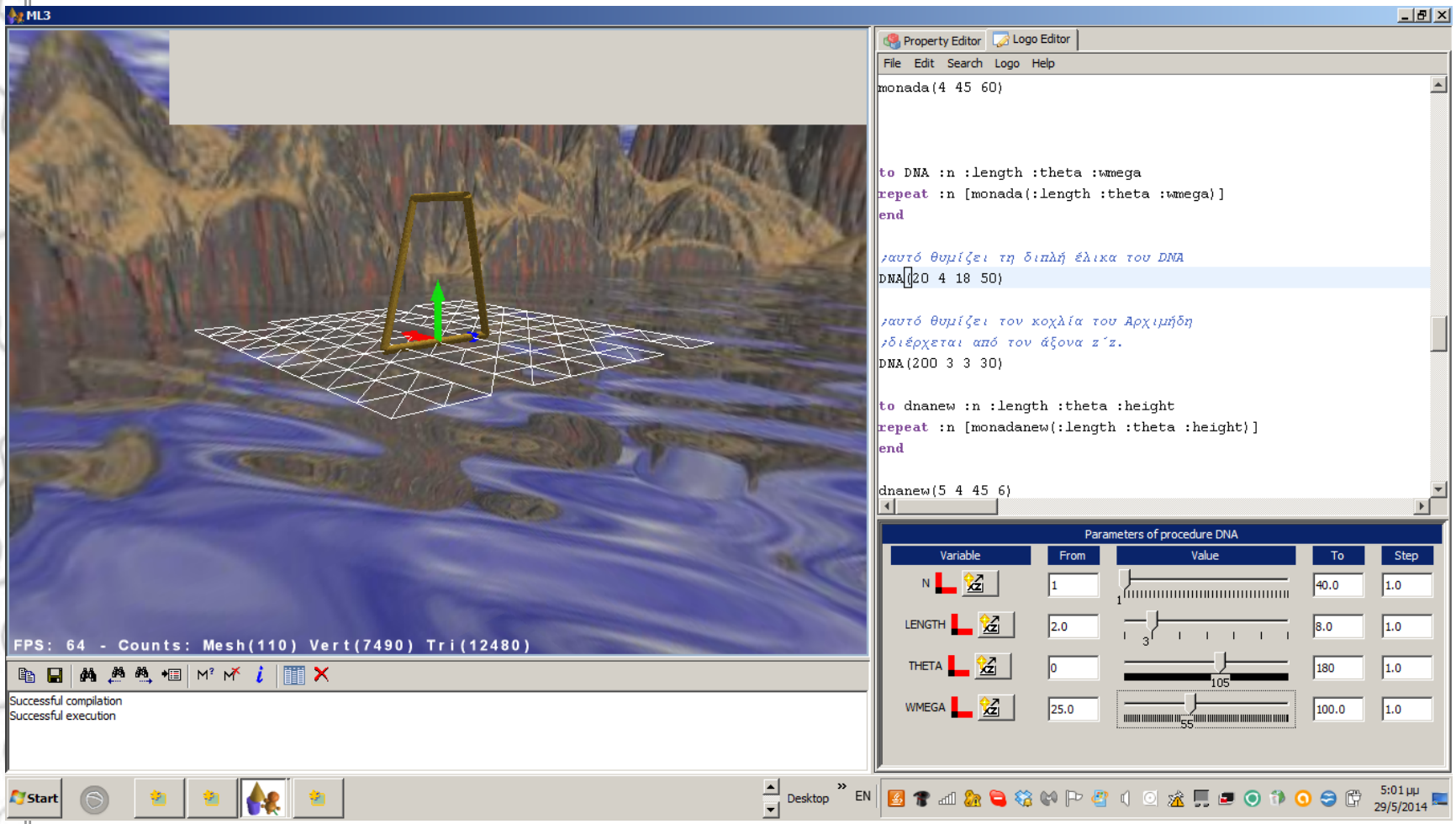
Intuitions: example n. 4

- A rectangle which is not a square


Χελωνόκοσμος
Μικρόκοσμος Ψηφίδα Εργαλεία Βοήθεια
Καμβάς
Συντάκτης
Monospaced
14
ώστε όταν το εκτελεί να βγαίνει πάντα
ένα τέτοιο παραλληλόγραμμο;
Κάνε κλικ στον πάπυρο, για να διαβάσεις
τις οδηγίες.
για παραλληλόγραμμο :χ :ψ
μ 100
δ 90
μ :ψ
δ :χ
μ 100
δ 90
μ 100
δ 90
τέλος
σβγ
παραλληλόγραμμο 80 70
Μεταβολέας
Διαδικασία: παραλληλόγραμμο
Μεταβλητή Από Μέχρι Βήμα
χ 40 160 1
68
ψ 35 140 1
86
Start
Desktop
EN

Intuitions: example n.5

- How does a twisted rectangle change?


ML3
FPS: 64 - Counts: Mesh(110) Vert(7490) Tri(12480)
Successful compilation
Successful execution
Property Editor
Logo Editor
File Edit Search Logo Help
monada(4 45 60)
to DNA :n :length :theta :wmega
repeat :n [monada(:length :theta :wmega)]
end
;αυτό θυμίζει τη διπλή έλικα του DNA
DNA(20 4 18 50)
;αυτό θυμίζει τον κοχλία του Αρχιμήδη
;διέρχεται από τον άξονα z΄z.
DNA(200 3 3 30)
to dnanew :n :length :theta :height
repeat :n [monadanew(:length :theta :height)]
end
dnanew(5 4 45 6)
Parameters of procedure DNA
Variable
From
Value
To
Step
N
1
40.0
1.0
LENGTH
2.0
8.0
1.0
THETA
0
180
1.0
WMEGA
25.0
100.0
1.0
Start
Desktop
EN
5:01 μμ
29/5/2014

Intuitions

- Newtonian trajectories (velocity – gravity) and collisions
- Physical vs virtual collisions and friction
- Mathematical equality vs balancing of a scale
- A rectangle which is not a square
- A twisted rectangle

Intuitions beyond physical phenomena

- Physical
- Mathematical (phenomenon – object – behaviour)
- Virtual
- Artificial (engineered)

What is special about the idea of intuitions

- Naïve experiential explanations
- Evocation and resistance
- Experiences with phenomena beyond the physical world
- Intuitions in a world with dense communication and mediation of digital artifacts

Emergent considerations for intuitions

- The ‘fade out’ process
- The ‘production’ process
  - Creating contexts to generate intuitions, the fading out of which may generate meanings