Universiteit Utrecht

[Faculteit Bètawetenschappen
FIsme]

Coherent education in proportionality in Science and Mathematics

SMEC September 2008

Ad Mooldijk

Freudenthal Institute for Science and Mathematics Education

Presentation

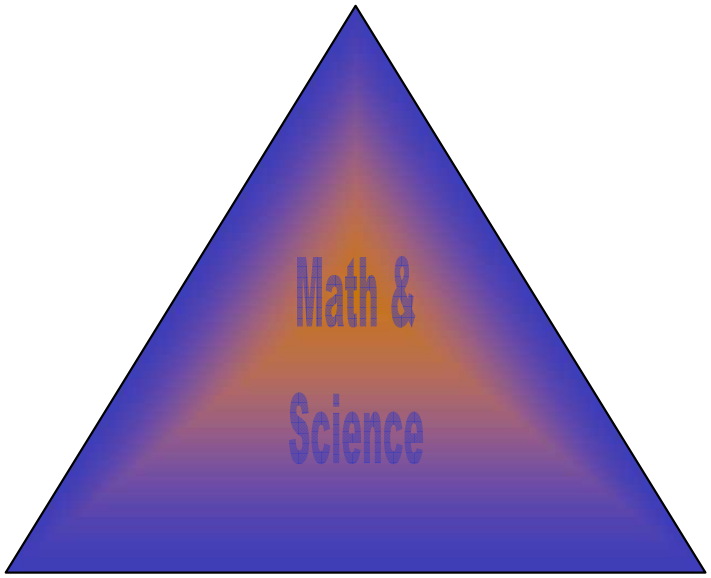
- Coherence in schools
- problems with the concept of proportionality and with reasoning from data
- Ideas in the SaLVO-project
- Structure.
- Findings
  - Students
  - Teachers
- How to start coherent teaching.

Coherence in schools

- Organizational
  - schedule
  - confer and support
  - room
- Subject matter
  - related concepts
  - hierarchy of subjects
- Didactics
  - Knowledge
  - approach
  - competence
  - method

Coherence triangle

Didactics



Organization

Subjects

Obstructions for coherence

- Ignorance contents of other subjects
- Connection own subjects within course
- Programs of subjects do not cohere
- Overload of subjects
- Organizational

proportionality

- No proportionality in math
- Different views
- Formula’s in physics
- y=ax vs $U=IR$
- Functions in math vs relations in physics

Basis of *SaLVO* 1

- Curriculum line, through subjects and classes
- Limited integration of subjects
- Proportional reasoning normative for the course
- Problem posing approach (also in math)
  - paragraph question
  - discussion
  - solidification of concept
  - consolidation

Basis of *SaLVO* 2

- Use mathematical skills explicitly within science
- multiple approach
  - words, graphs, functions
- Use of ict, (excel, graphical calculator)
- Recognizable contexts
- teachers are familiair with each subject

The learning path in modules (lower sec.)

1	proportionality in form 2	Ma	F2
2	proportionality and density in physics	Ph	F2
3	enlarging and reducing	Ph; Ma	F2
4	inverse proportionality	Ma	F3
5	economy and percent	Ec	F3
6	chemical reactions	Ch	F3
7	formules and proportionality	Ph	F3
8	exponential relations	M/P/I/	F3
A	The Planets	Ph	F3

The learning path in modules (upper sec.)

8	powers and proportionality	Ma	F4
9	relations in research	Ph	F4
10	exponential relations	Ma; Ph	F5
11	modeling and math	Ma; Ph	F5 F6
12	periodic relations	Ma; Ph	F5
13			

Findings from students (interviews, enquetes, assignments

- Students don’t like the material, the modules are not easy and the projects are more demanding than the projects they are used to.
- Students, especially female, think they master working with proportionality.

Findings from teachers

- Students are better in working with proporionality and formules as before, not only students that choose physics but also students that take a more cultural educationprogram in upper secondary
- Also the math is improved!
- More students choose for a science-related program in upper secondary (but…)
- Metaview helps students

Start with Coherent teaching?

- Coherent teaching = team teaching
- Speak with colleagues about collective subjects and learn what they mean with it.
- Learn what they teach in other courses (and in other schools)
- Develop a collective vision about coherent education.
- Visit each others lessons and see how different teaching is in other subjects.
- Start with a small coherent project

Summary how to master coherence

- Organisation, content and didactics
- Retraining together with other subjects
  - content
  - didactical approach
- Support from the heads of school.

Thank you

- mooldijk@uu.nl
- www.salvoproject.nl

Example of working with a module Exponential functions (F3)

- Exponential growth vs lineair growth
- Multiple approach
  - Words, graphs, formules
  - One concept, different contexts and subjects
  - Study of the exponential behaviour (ma), discovery of exponential behaviour (Ph)
- Powers of ten and the calculator
- Coherence in different subjects
- Paragraph Questions

Example - Findings

- The year after, math-teachers were enthusiastic about the skills of the students, knowledge about growthfactor…
- Students are not very enthusiastic about the project, but do like it better afterwards
- The assignments were made well.
- Experiments added validation to het more theoretical part.
- New schools also like the project as a start (for teachers) to begin with coherent teaching with SaLVO

Exponentials

- 4 parts, A – D, each 2 lessons from 50 min.
- After part A-D an 1hour test
- E: investigation + poster presentation in 4 lessons
- Lower secondary education; age 14 -15
- 2006: test in 3 groups => Rewrite
- 2007: test in 15 groups

t A

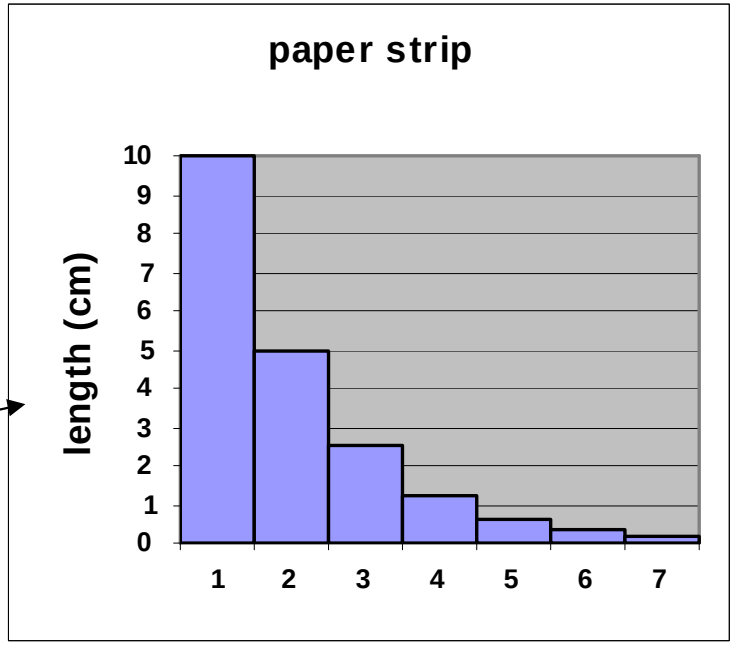
- The powers of ten
  - Java-applet: from the Milky Way to the DNA
  - rules e.g. $10^a.10^b = 10^{a+b}$
  - calculations e.g. what's the time for sunlight to reach Pluto?
- Other bases
  - calculations
  - rules
- Extra: binary counting

$$a^p \cdot a^q = a^{p+q}$$
$$a^p / a^q = a^{p-q}$$
$$a^0 = 1$$
$$a^{-p} = 1 / a^p$$

Part B

- **Linear** growth
  - every fixed (time) step results in a fixed **addition**
- **Exponential** growth
  - every fixed (time) step results in a fixed **multiplication**

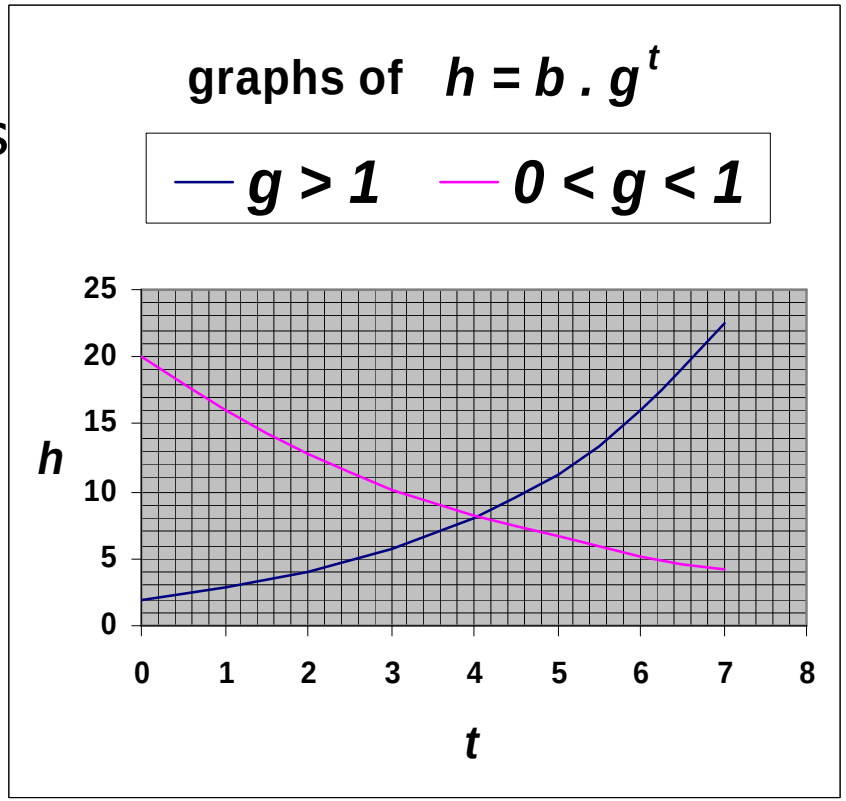
  - e.g. growth of bacterium E-coli
  - growth factor g = new / old
  - interest p % => $g = 1 + p/100$
  - decay
    - length of paper strip $l = 20 \cdot 0{,}5^n$
  - a lot of exercises in science context



Part C

- Excel
  - exercises to acquire the skills
  - e.g. tables and graphs

  - lot of exercises
    - physics, economics
    - growth factor *g*
    - interest *p*%



Part D

- Atomic model
  - proton, neutrons
  - isotopes
  - radiation, activity, Bq
  - X-ray, α , β , γ

  - radioactive decay
  - half-life -> g = 0,5

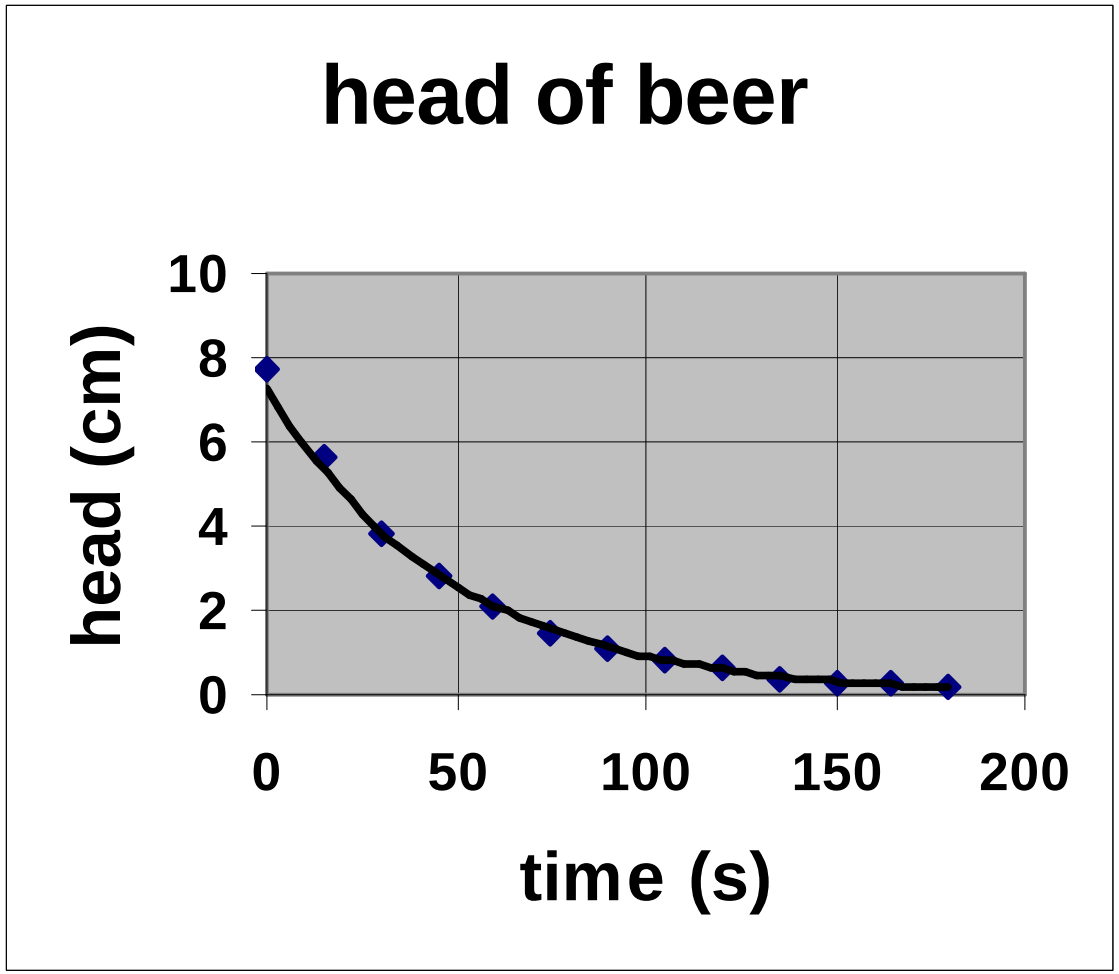
  - Formula $A = A_0 \cdot 0{,}5^{n}$

  - ‘measuring’ with Java-applets

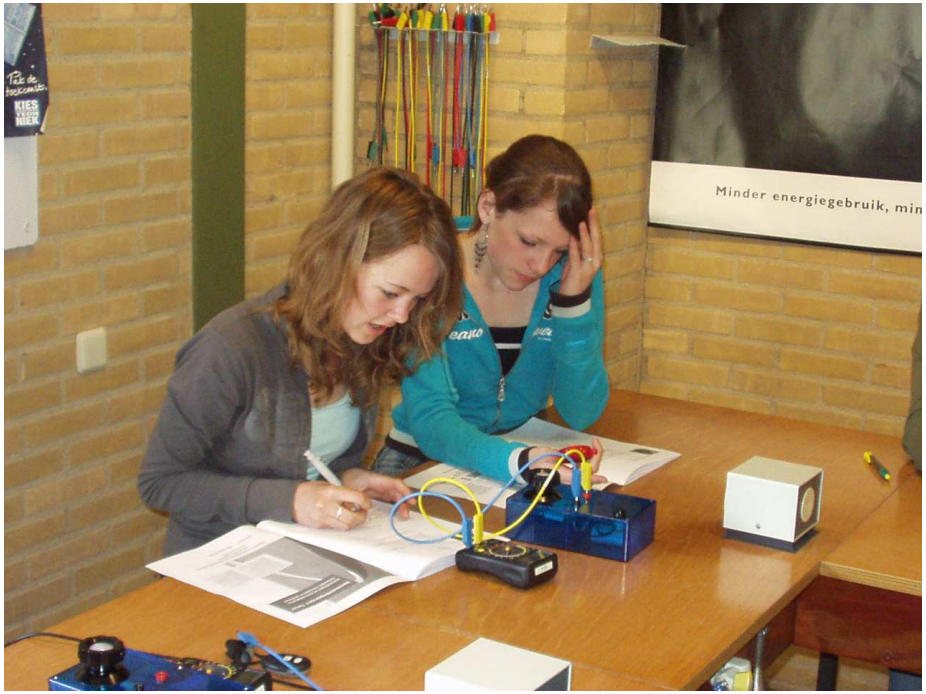
Part E

- Groups of 3
- 11 different little investigations
  - decay of the head of beer
  - Moores Law
  - oil and water cool off
  - discharging of a capacitor
- Assignment
  - growth factor *g*
  - formula of the exponential fur
  - graphs in Excel
  - presentation (4 min)

Results of a group



$$h = 7{,}2 \cdot 0{,}73^{t/15}$$


Minder energiegebruik, min


het broeikasgevaar.
Minder energiegebruik, minder broeikasgevaar.
UPGRADED
1976


1936


AFKOELING
VLOEISTOFFEN
1 UUR
WATER
GREENWICH


aardolie


BIERSCHUM

after a good days work …