UNIVERSITY OF APPLIED SCIENCES UTRECHT

Multimedia representations in problem solving in mathematics education: An augmented reality example

ATEE Winter conference 2018
Technology and Innoivatoive learning
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Thursday, 15 february 2018

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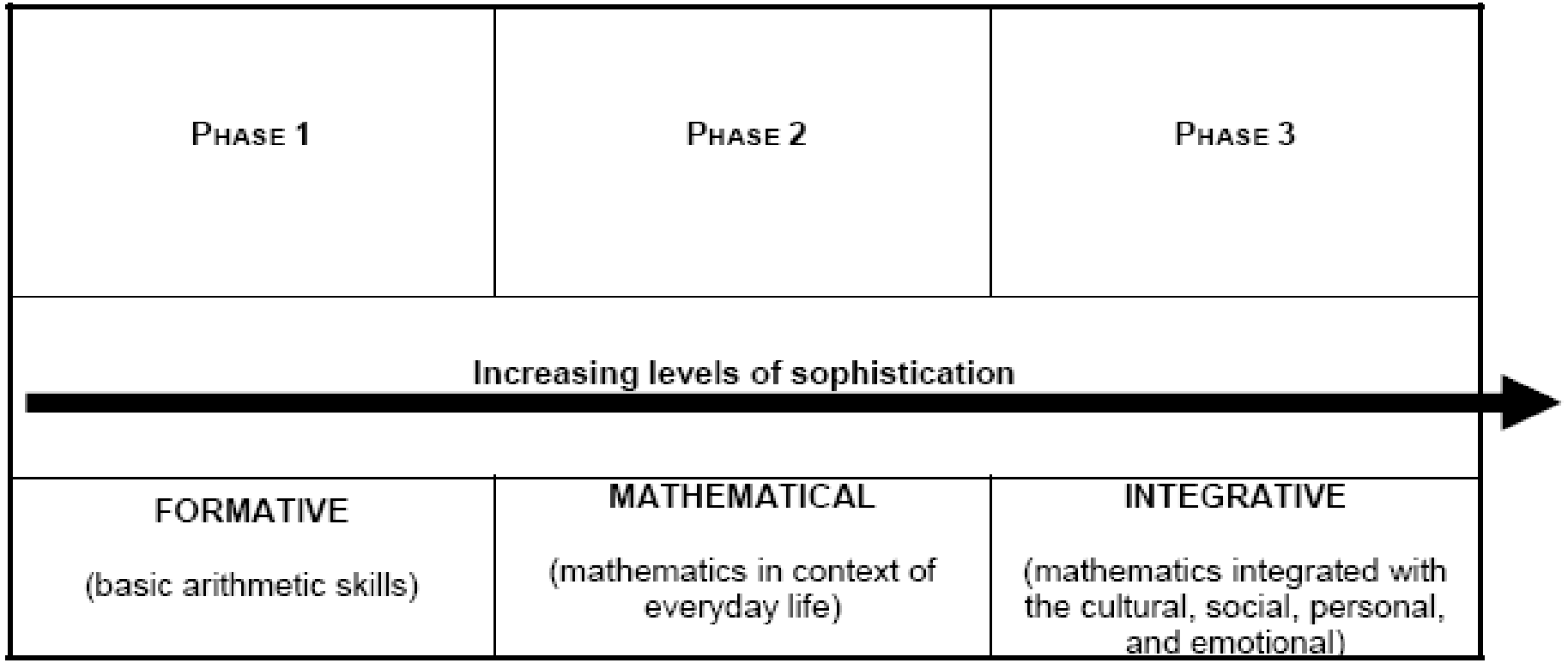
Overview of presentation

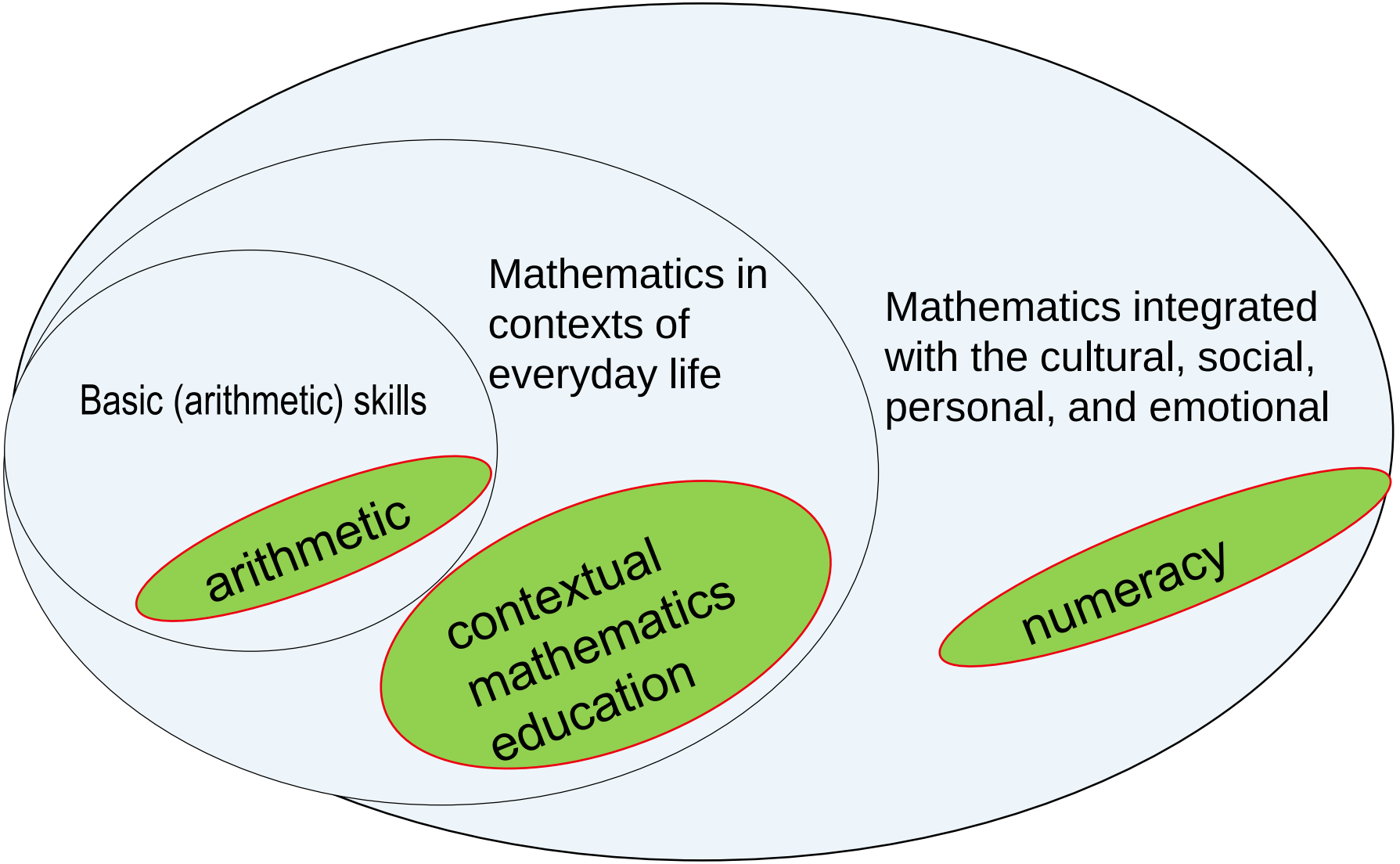
- Mathematics / Numeracy / Mathematical Literacy
  - Sophistication of numeracy concepts
- Designing representations of reality for classroom practice
- Recent research results
- Design aspirations

Adult Numeracy Concept Continuum of Development



A continuum of development of the concept of numeracy showing increased level of sophistication from left to right (from Maguire & O'Donoghue, 2002)

Numeracy & Functional Mathematics Conceptual Development



9.65

a. $\frac{5}{33} + \frac{9}{22} =$

b. $\frac{7}{24} - \frac{3}{16} =$

c. $\frac{13}{12} + \frac{4}{15} =$

d. $\frac{4}{9} \times \frac{4}{11} =$

e. $\frac{7}{5} : \frac{5}{7} =$

9.68

a. $\dfrac{\frac{5}{6} + \frac{2}{5}}{\frac{2}{3} + \frac{1}{6}} =$

b. $\dfrac{\frac{3}{4} + \frac{4}{3}}{\frac{3}{4} - \frac{1}{3}} =$

31 Jan knapt zijn slaapkamer op. Hij gaat de drie wanden lichtblauw verven. Hij heeft 5 liter verf gekocht, genoeg voor 30 m^2.

a De eerste muur heeft een oppervlakte van 4 m^2. Hoeveel verf heeft Jan voor deze muur nodig? Gebruik een verhoudingstabel.

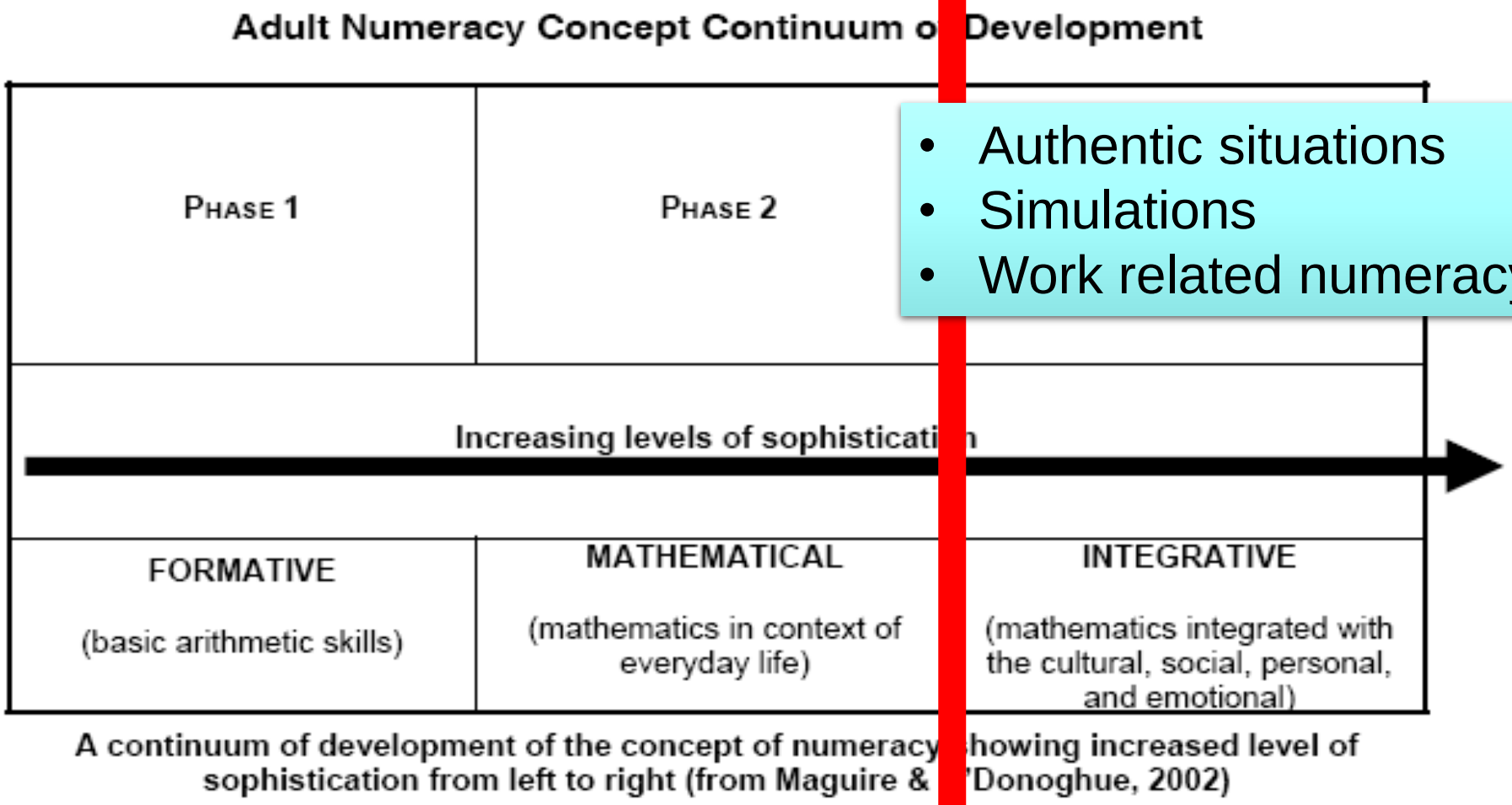
b De volgende muur heeft een oppervlakte van 10 m^2.

realistic mathematics education

arithmetic

numeracy

Gecijferdheid

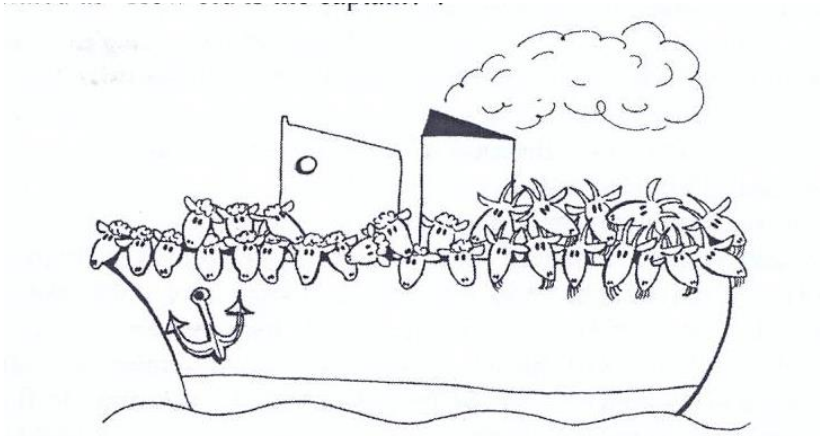


- Authentic situations
- Simulations
- Work related numeracy

Age of the captain

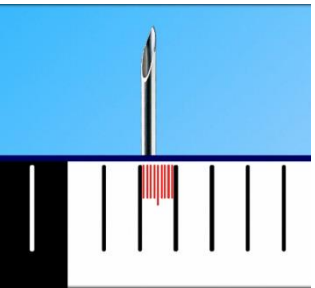
A captain owns 26 sheep and 10 goats.
How old is the captain?

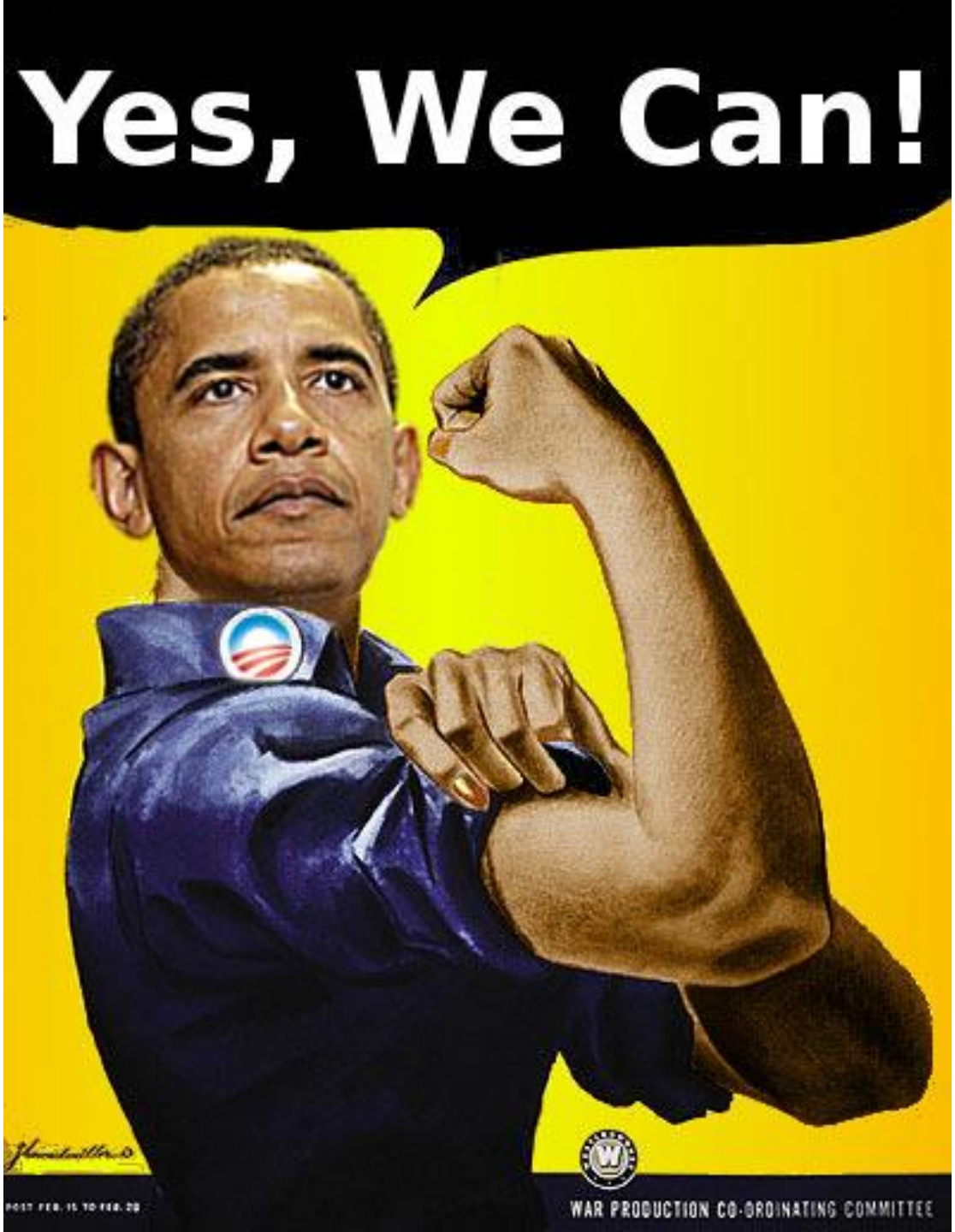
- Suspension of sense making
- Calculational approach



Puisque tu fais de la géométrie et de la trigonométrie, je vais te donner un problème : Un navire est en mer, il est parti de Boston chargé de coton, il jauge 200 tonneaux. Il fait voile vers le Havre, le grand mât est cassé, il y a un mousse sur le gaillard d'avant, les passagers sont au nombre de douze, le vent souffle N.-E.-E., l'horloge marque 3 heures un quart d'après-midi, on est au mois de mai… On demande l'**âge du capitaine** ?
Flaubert, 1841

Can we improve “regular“ lesson materials and “regular” tests to fit more sophisticated numeracy concepts?




Yes, We Can!
WAR PRODUCTION CO-ORDINATING COMMITTEE

Apples are sold in 2.5 kilogram bags.
You weigh one apple and find 157 grams.

About how many apples are there in one bag?

[ ] apples

You buy groceries for a total of € 21.30
You pay with a 50 euro bill and two coins of 1 euro.

How much is the change?

€ [ ]

The bath room has two windows.
They both are 0,90 m in width and 1,35 m in height.
You want to double glaze these windows.
Double glazing costs € 148,- per m^2

What is the cost of double glazing these windows?
€ [ ]

About how many apples are there in one bag?

[ ] apples

Je moet betalen

Je betaalt met

You have to pay:

You pay with:

SUPERMARKT

Daliastraat 4
5707 SJ Helmond
0492-527384

15	blik cola 330ml	0.90	13.50
13	chips flav. pnt. light	0.60	7.80
aantal art. 28		subtotaal	21,30
TOTAAL			21.30

How much is the change?

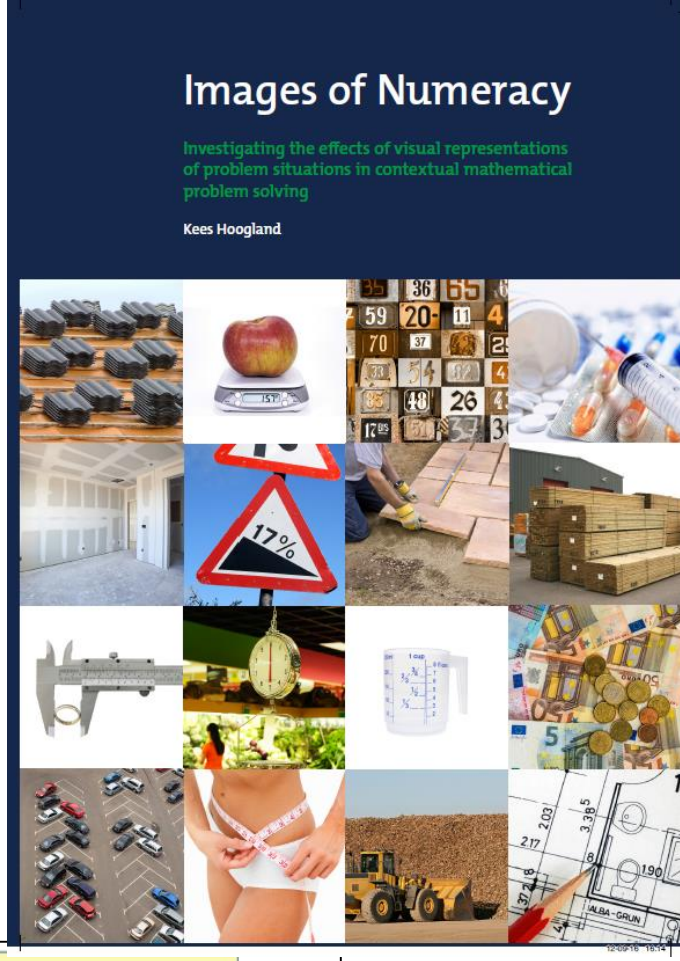
€ [ ]

Double glazing
€ 148.- per m²

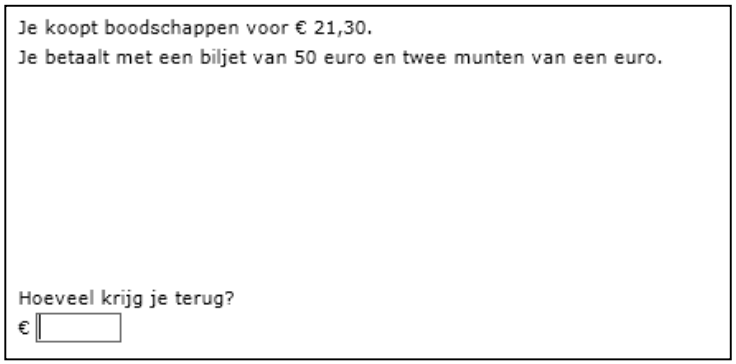
What is the cost of double glazing these windows?
€ [ ]

Images of Numeracy

Investigating the effects of visual representations of problem situations in contextual mathematical problem solving



From a descriptive representation of reality to a depictive representation of reality.



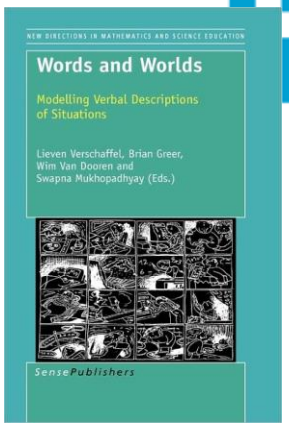
Research design

- 24 items in two equivalent versions A and B:
  - A = descriptive representation
  - B = depictive representation
- Large scale testing as a numeracy test:
  - random 12 A + 12 B, random order
  - controlled randomized trial
- Research question: What is the effect of item characteristics on students' results?

Theoretical notions

- Contextual (word) problems & their difficulties

  (Boaler, 1993), (Gravemeijer, 1994),
  (Verschaffel et al. 2000, 2009), Greer (1997)
  and many more



- Cognitive psychology
  - descriptive versus depictive representations

    (Schnotz et al., 2002, 2010)

- Cognitive load theory

  (Sweller, 1996, 1999; Mayer, 2005)

- "Answer getting mindset" versus "Problem solving mindset"

  (Boaler, 2016), (Daro, 2013)

Data

- Main run
  - 179 schools
  - 31,842 students
  - Primary (11-12 yr)
    - 1,150
  - Secondary (12-16/18 yr)
    - 29,500
  - Sec. vocational (16-20 ytr)
    - 1,000

- Collected data
  - Scores on items
  - Answers to items
  - Grade level
  - School track level
  - Age
  - SES
  - Gender
  - Ethnicity
  - Time spent on items in ms
  - Last math grade

Statistical analysis

Probit – analysis is a sophisticated multivariate analysis

How do the variables v (version) and x (others) contribute to the ability y.
The chance P(z = 1) that the question is solved correctly equals
the chance P(y ≥ δ) that ability y surpasses a treshold δ.

$$y = \alpha_0 + \alpha_1 v + \alpha_2 x + \varepsilon$$

$$z = 1 \text{ if } y \geq \delta$$
$$z = 0 \text{ otherwise}$$

$$P(z = 1) = P(y \geq \delta) = P(\varepsilon \geq -\alpha_0^* - \alpha_1 v - \alpha_2 x)$$
$$P(z = 0) = 1 - P(y \geq \delta)$$
$$\text{with } \alpha_0^* = -\delta + \alpha_0$$

v = {0 = descriptive repr., 1 = depictive repr. }
x_1 = {0 = male,1 = female}
x_2 = {0 = not, 1 = migrant family}
x_3 = {relative age within level grade}
x_4 = {last school math grade}
x_5 … x_9 = {school track level}

E = not observed variables (m=0, s=1)

From the data the parameters α_0^*, α_1, α_2 are estimated by maximum likelihood.

Results

Independent variables		Model 1 marginal effect (std.err.)	Model 2 marginal effect (std.err.)	Model 3 marginal effect (std.err.)
v	variant (verbal/image-rich)	0.0207(0.0013)(*)	0.0207(0.0013)(*)	0.0197(0.0025)(*)
x_1	gender	0.0524(0.0013)(*)	0.0509(0.0013)(*)	0.0509(0.0013)(*)
x_2	etnicity	-0.0288(0.0015)(*)	-0.0267(0.0016)(*)	-0.0266(0.0022)(*)
x_3	age (relative)		-0.0124(0.0010)(*)	-0.0124(0.0010)(*)
x_4	math grade		0.0208(0.0005)(*)	0.0208(0.0005)(*)
x_5	primary education (rel.)	-0.1900(0.0034)(*)	-0.2183(0.0037)(*)	-0.2185(0.0052)(*)
x_6	pre-vocational (rel.)	-0.1810(0.0015)(*)	-0.1856(0.0019)(*)	-0.1863(0.0022)(*)
	general secondary	reference		
x_7	secondary vocational (rel.)	0.0859(0.0035)(*)	0.1020(0.0036)(*)	0.1006(0.0053)(*)
x_8	pre-university (rel.)	0.1136(0.0017)(*)	0.1029(0.0018)(*)	0.1021(0.0025)(*)
x_9	school level	0.0845(0.0007)(*)	0.0899(0.0008)(*)	0.0899(0.0008)(*)
v * x_2	variant *etnicity			0.0001(0.0032)
v * x_5	variant * primary education			0.0006(0.0093)
v * x_6	variant * pre-vocational			0.0015(0.0032)
	variant * general secondary			reference
v * x_7	variant * secondary vocational			0.0029(0.0075)
v * x_8	variant * pre-university			0.0017(0.0035)
	N	646,275	605,430	605,430
	Pseudo R2	0.0647	0.0676	0.0676

Results

- B > A statistically significant, with a (very) small effect size.
- B > A on a significant number of problems (11/21)
- Bigger effect in domain of measurement & geometry

- Further research
  - Interdependency on other variables
  - Actual student behavior
  - Eye-tracking
  - Teaching focus

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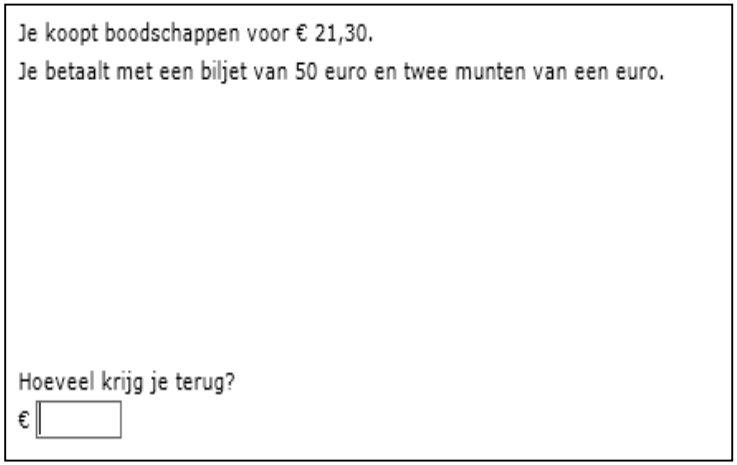


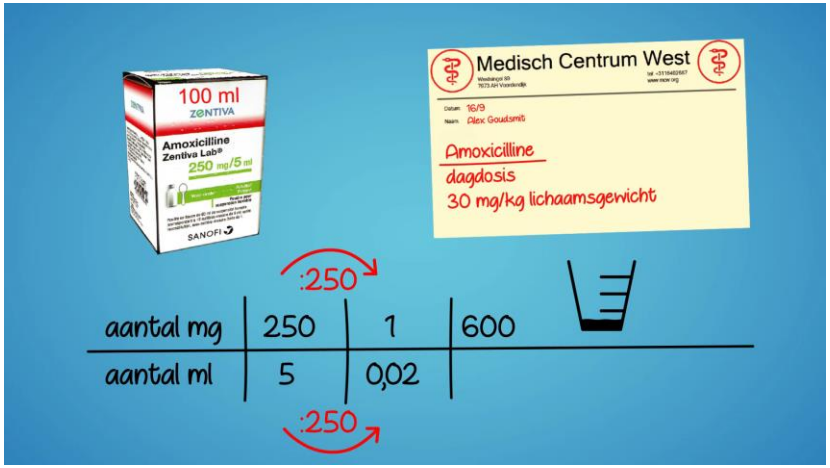
Broader perspective

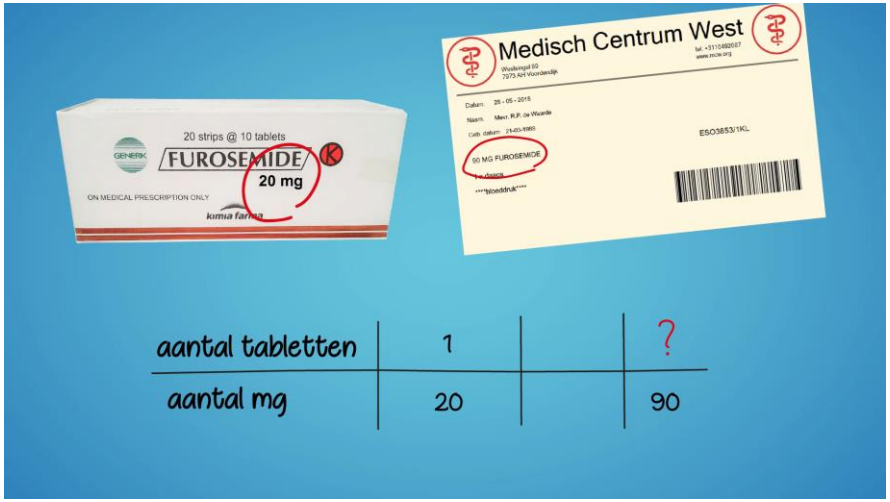
- Simulating "reality" in classroom context
  - Verbal / descriptive
  - Visual / photographs / depictive
  - Visual / video clips / animated
  - Visual / augmented reality /

Videoclips

- http://www.ffrekenen.nl/versie1/content/theorie/verhoudingen/r01_th_vh_018

Video and animated explanation





Augmented reality

- Bringing reality into the classroom and activate the overlay.

Technology: When the situation is detected, the overlay is activated

AURASMA

Education: When the relevant numeracy situation is detected, the educational overlay is activated

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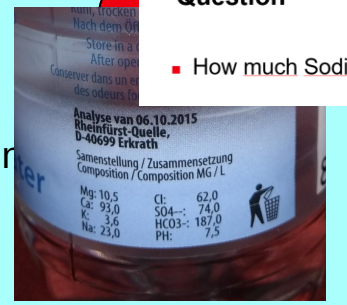
Situation i

Situation



Question

- How much Sodium is in this bottle?

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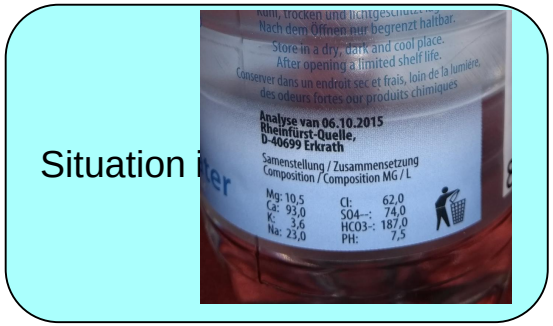

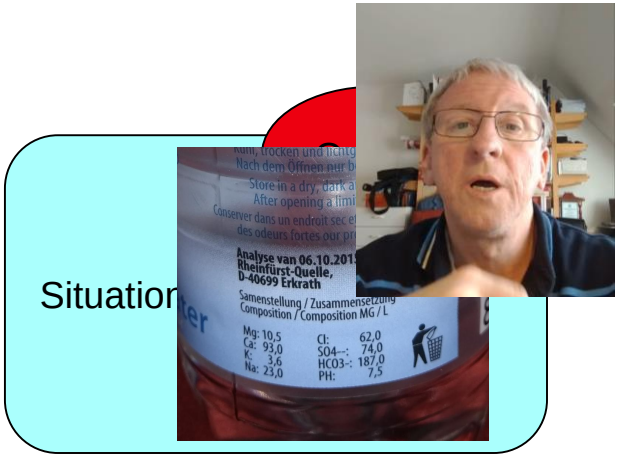

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Situatio

How many bags of patato chips can you buy with 10 euro's ?

ity

Technology: When the situation is detected, the overlay is activated

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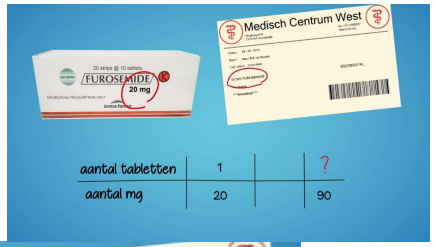

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AURASMA

Augmented reality

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AURASMA

Which App to use

To create (teacher or student):

Aurasma App (Mobile phone)

Aurasma Studio (PC)

To activate (student):

Aurasma / HP Reveal app

(Mobile Phone / Tablet)

Contact

Thank you for your attention !!

More information or suggestions?

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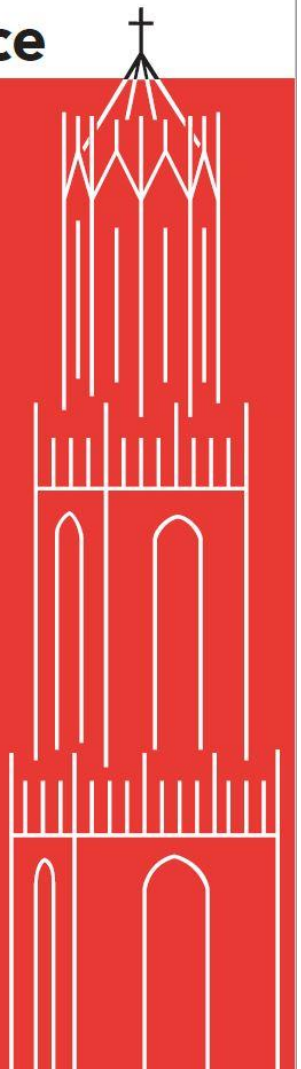
Association for Teacher Education in Europe

HOGESCHOOL UTRECHT

ATEE Winter Conference

Technology and Innovative learning

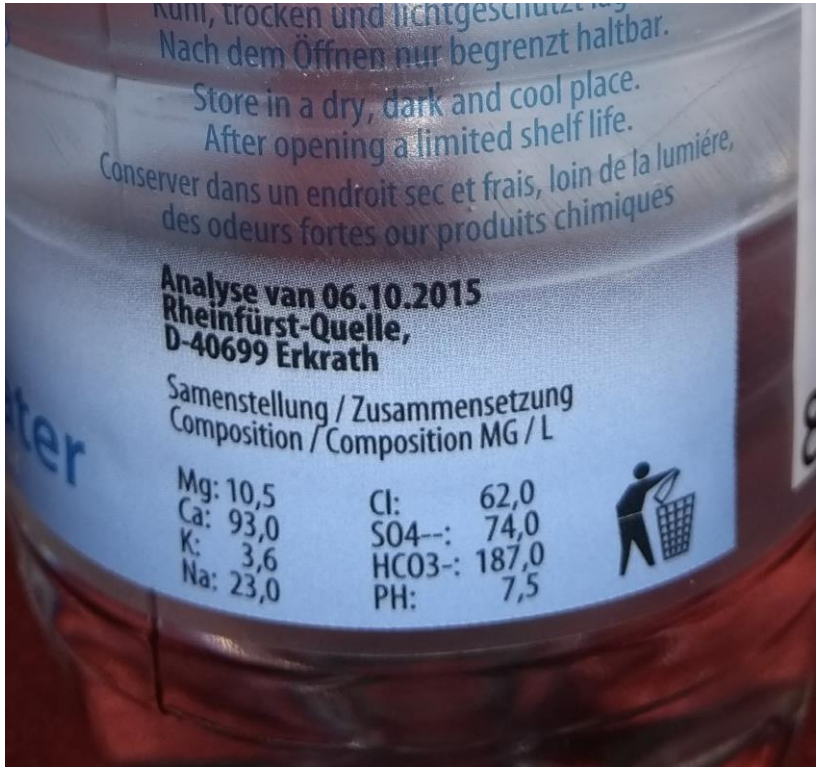


Programme

15-16 February 2018
Utrecht, Netherlands


25.00
Lay's
wavy
Baked!


Natürliches Mineralwasser ohne Kohlensäure
Natural mineral water non-carbonated
Eau minérale naturelle sans gaz
Bewaren op een droge, donkere en koele plaats.
Na openen beperkt houdbaar.
Kühl, trocken und lichtgeschützt lagern.
Nach dem Öffnen nur begrenzt haltbar.
Store in a dry, dark and cool place.
After opening a limited shelf life.
Conserver dans un endroit sec et frais, loin de la lumière,
des odeurs fortes our produits chimiques
Analyse van 06.10.2015
Rheinfürst-Quelle,
D-40699 Erkrath
Samenstellung / Zusammensetzung
Composition / Composition MG / L
Mg: 10,5
Ca: 93,0
K: 3,6
Na: 23,0
Cl: 62,0
SO4--: 74,0
HCO3-: 187,0
PH: 7,5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Question

How much Sodium is in this bottle?

Question

How many bags of patato chips can you buy with 10 euro’s ?

Question

- How much Sodium do you consume?