Integration of ICT in Science Education

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Mind, Brain and Education
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AMSTEL Institute

Amsterdam Mathematics, Science and Technology Education Laboratory

A research facility of the Faculty of Science to improve M&S Education in general, and to strengthen the link to secondary education. Some activities:

- (International) Master Mathematics & Science Education, and teacher preparation
- Science/Math Ed Research
- Expert center for Dutch Ministry of Ed for ICT in Science Education
- Appr 35 staffmembers

Demands for Learning Environment for MST

- Reflect innovation in Science itself
- Helps to bridge gap to real life context
- One integrated tool: frequently use, only once to learn
- Open to teachers and learners
- Authoring facilities to create tailor-made activities

‘When a student opens a university text, he/she is almost always left feeling that that field of study is a closed chapter. I is very rare that he/she finds a chance to discuss or learn about problems that are still open.’

Antonino Zichichi

A highschool student project ..

- In grade 11/12 students have to do an own investigation/project, 80 hours
- Come up with own idea
- Gather information
- Pose the research question
- Design the experiment
- Compare with literature

The winners in 2003: Niek Dubelaar en Remco Brantjes

- They found an article (Menz, TPT 93) on the web talking about acceleration larger than g during bungee jumping
- Their report

What did they do - 1

- Their starting point in fact was a>g during phase in which the jumper is ‘catapulted’ by the bungee.
- Their research question deals with the phase before the bungee get stretched, and in fact is of much more interest ...

What did they do -2

- They did use video measurement, but experienced that this is not that straightforward, and
- They found a new article and learned the effect will be more dramatic in case the bungee is relatively heavy compared to the jumper: new experiments

What did they do - 3

- They claim reasonable results up to a=3.9 g (ratio m/M=3.5) in this second experiment,
- They give the theory/explanation, based on an article of David Kagan and Alan Kott (TPT vol.34, sept 1996)
- They won second price in a competition of University of Amsterdam
- An Article in the NTvN: Journal of the Dutch Physical Society, October 2003

Reactions ..1

- Next issue: just an editors remark,
- ‘many reactions, next issue etc’
- December 2003 issue, an overview by the editor of the reactions

- A number of physicists doubted the quality of present education in physics at highschools ….(no names given by the editor)

Reactions 2

- Several took the contribution serious and tried to give as elegant as possible explanations (names given)
- Biezeveld (physics teacher) referred to his article in TPT (Vol.41, April 2003). He reported about a measurement of position with Coach, and a model calculation based on Kagan and Kott.

Reaction Hewitt to Biezeveld

- Biezeveld did receive a reaction from Paul Hewitt: ‘I did a Figuring Physics on it two January's ago. Not having the space to give a convincing explanation as your article supplies, I was booed by many. A website among teachers cried "Hewitt Blew it!"

Reaction 3: two theoretical physicists, Pasveer and De Muynck

Our interpretation is Galilean, so

- Or we start to doubt the results
- Or we start to look for the extra force

- Both approaches not acceptable, better focus on the system of jumper + moving part of bungee, and only take Fg

Newton's second Law 1

- We are used to F=m.a, so an acceleration a needs a force F as a cause
- But correct is F = dP/dt ; P = m.v, and for time dependent mass:

$$F = v.dm/dt + m.a$$

And because F = m.g and dm/dt < 0 follows a>g

Newton's Second Law 2

- They further derive the formula for a-g and have solved the differential equation numerical for different values of the parameter m/M
- Effect is caused pure due to diminishing mass, no matter how this is done

Why we have problems to understand?

- We are so much used to the paradigm ‘every acceleration needs a force’ that we tend to see v.dm/dt as a force. But then we need to move this term to the other side..
- This is what Newton did when he interpreted inertia forces. He interpreted the effect of a choice of the coordinate system as a Force. Einstein was needed to repair this and returned the term to the other side ..

Development Process

- Multi-disciplinary team of science educators, curriculum developers, teachers, software and hardware experts
- Input from research, in-service training, curriculum development, teachers/users, publishers ...

Main Concept of Coach

"Open" learning environment that offers universal tools, which can be used to solve many different problems.

Important aspects...

- Such environment should change the computer into an instrument and give the learner power to explore, measure and learn from the physical world (real-life situations)
- Should be structured to encourage an inquiring approach to science.

Important aspects...

- Give opportunities to work like a scientist with possibilities to collect data, control experiments, measure on video, analyze and process data, create computer dynamical models,
- Should be universal for using with many different curricula

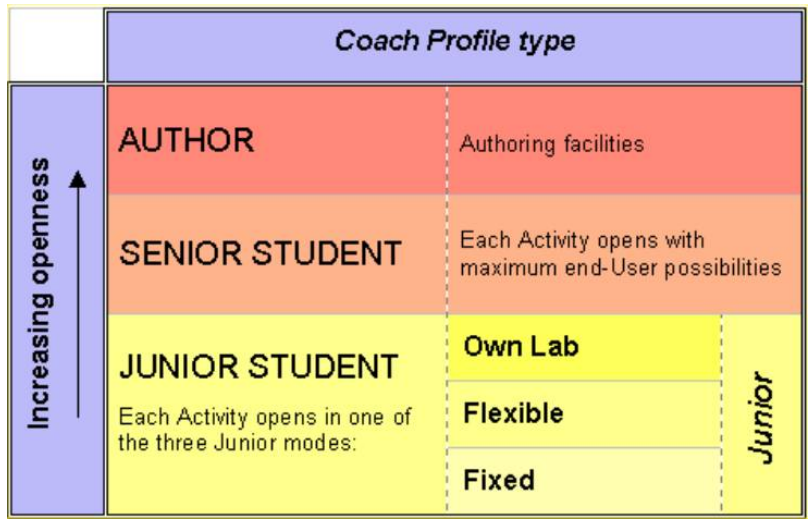
After > 20 years: Coach 6

Integrated tools for

- Measurement (online and off line)
- Modeling
- Video measurement (and capturing)
- Processing and analysis of data
- Control and robotics
- Authoring by teacher/curr. developer

Coach 6 – Authoring environment

- Allows curriculum developers (teachers, textbook authors) to create multimedia activities with their own learning content
- Offers management tools for teachers
- Can be customized to be used by students starting at primary up to undergraduate level (age 10 to 20)

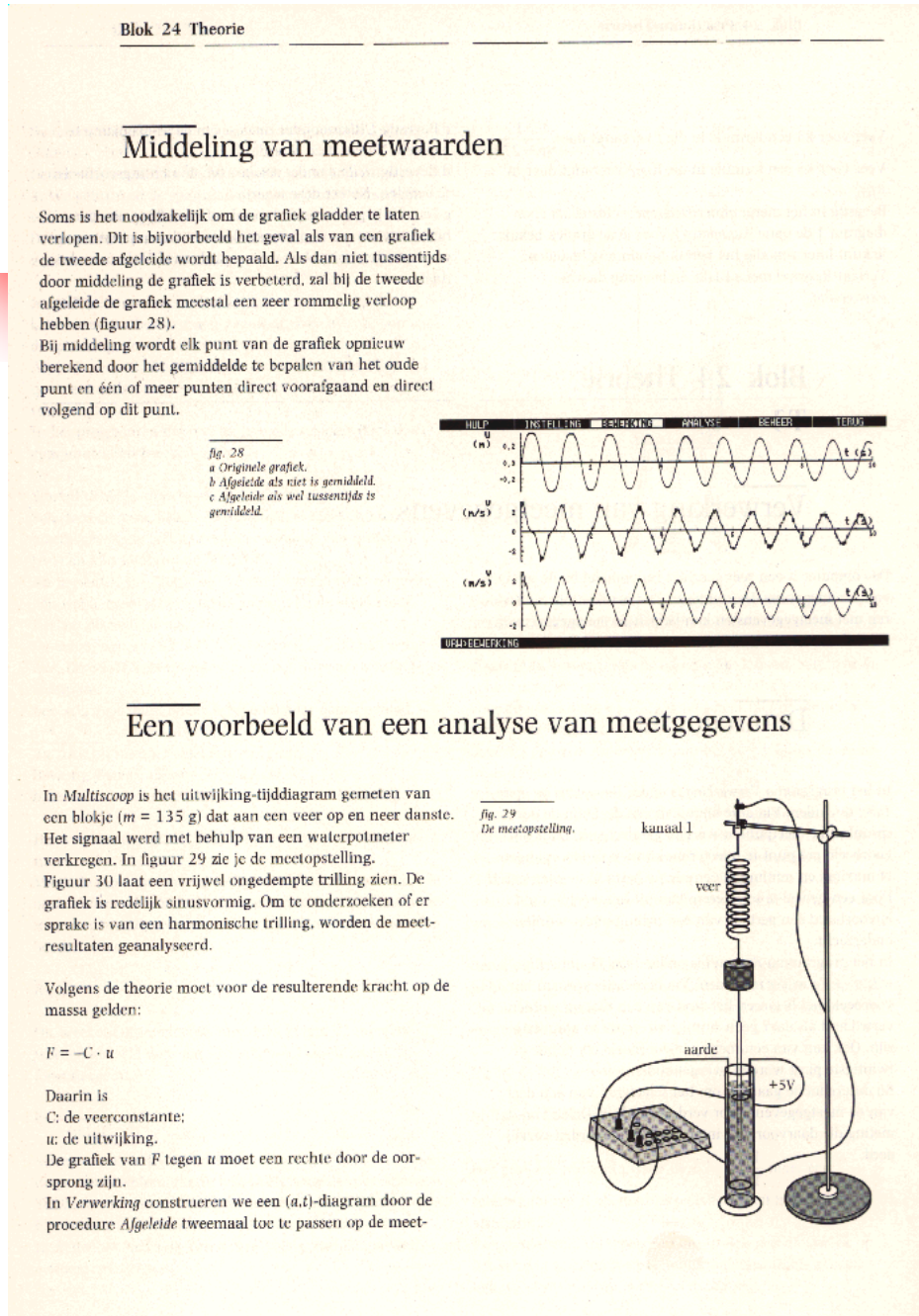


Some examples

- Video measurement
- Modelling
- Mesurement, also for primary school level

Curriculum Physics (Chemistry, Biology and Technology)

- Domain ‘Skills’
  - a pupil is able to use a computer for measurements, spreadsheets, simulations
  - a pupil is able to control automated systems
- In other , discipline oriented, domains use of ICT is stated in some of the goals, f.i.:
  - a pupil is able to measure position and velocity with a sensor and computer



Blok 24 Theorie

Middeling van meetwaarden

Soms is het noodzakelijk om de grafiek gladder te laten verlopen. Dit is bijvoorbeeld het geval als van een grafiek de tweede afgeleide wordt bepaald. Als dan niet tussentijds door middeling de grafiek is verbeterd, zal bij de tweede afgeleide de grafiek meestal een zeer rommelig verloop hebben (figuur 28).
Bij middeling wordt elk punt van de grafiek opnieuw berekend door het gemiddelde te bepalen van het oude punt en één of meer punten direct voorafgaand en direct volgend op dit punt.

fig. 28
a Originele grafiek.
b Afgeleide als niet is gemiddeld.
c Afgeleide als wel tussentijds is gemiddeld.

Een voorbeeld van een analyse van meetgegevens

In *Multiscoop* is het uitwijking-tijddiagram gemeten van een blokje (m = 135 g) dat aan een veer op en neer danste. Het signaal werd met behulp van een waterpotmeter verkregen. In figuur 29 zie je de meetopstelling.
Figuur 30 laat een vrijwel ongedempte trilling zien. De grafiek is redelijk sinusvormig. Om te onderzoeken of er sprake is van een harmonische trilling, worden de meetresultaten geanalyseerd.

Volgens de theorie moet voor de resulterende kracht op de massa gelden:

$F = -C \cdot u$

Daarin is
C: de veerconstante;
u: de uitwijking.
De grafiek van F tegen u moet een rechte door de oorsprong zijn.
In *Verwerking* construeren we een (a,t)-diagram door de procedure *Afgeleide* tweemaal toe te passen op de meet-

fig. 29
De meetopstelling.

Page of textbook

- *Level:* upper secondary (16-17 year)
- *Activity:* processing and analysing of data, damped oscillation

Questions from national exams

Het rendement van de swing wordt gedefinieerd als de bewegingsenergie van de ball na de slag gedeeld door de bewegingsenergie van het uiteinde van de club vlak voor het contact met de ball. De massa van het uiteinde van de club is 450 g en de massa van de ball is 85 g. De snelheid van de ball bij het loskomen was 63 $m\,s^{-1}$.

3p **16** □ Bereken het rendement van de swing.

Bij de botsing tussen het uiteinde van de club en de ball blijft de impuls behouden, maar wordt een deel van de kinetische energie omgezet in warmte.

4p **17** □ Bereken hoeveel energie er bij de botsing in warmte wordt omgezet.

De ball ondervindt op weg naar een holte in de grond (de 'hole') een luchtwrijvingskracht F_w die evenredig is met het kwadraat van zijn snelheid. Voor deze ball is de evenredigheidsconstante k gelijk aan $1{,}8 \cdot 10^{-3}$ $kg\,m^{-1}$.
De baan van de ball wordt gesimuleerd met het volgende rekenkundige model, dat nog niet volledig juist is:

model

MODEL		STARTWAARDEN	
$dx = v_x * dt$ $x = x + dx$ $dy = v_y * dt$ $y = y + dy$	*blok* A	$x = 0$ $y = 0$ $v = 63$ $\alpha = 25$ $k = 0{,}0018$ $m = 0{,}085$ $g = 9{,}81$ $dt = 0{,}005$ $t = 0$ *Startwaarden* v_x *en* v_y*:* $v_x = v * \cos\alpha$ $v_y = v * \sin\alpha$	m m m/s graden kg/m kg m/s^2 s s
$a_x = \ldots$ $a_y = -g + F_{wy}/m$ $dv_x = a_x * dt$ $v_x = v_x + dv_x$ $dv_y = a_y * dt$ $v_y = v_y + dv_y$ $t = t + dt$	*blok* B		
$\alpha = \arctan(v_y/v_x)$ $v = \ldots$ $F_w = -k * v * v$ $F_{wx} = F_w * \cos\alpha$ $F_{wy} = F_w * \sin\alpha$	*blok* C		

OPMERKING: arctan = $\tan^{-1}$ = invtan

De computer rekent alle regels van het model na elkaar uit. Voor de variabelen achter de = tekens gebruikt hij de startwaarden of de waarden die hij in eerdere regels heeft berekend. Als hij alle regels heeft doorgerekend, begint hij opnieuw bovenaan om alle grootheden voor een volgend tijdstip te berekenen. Dan gebruikt hij steeds de laatste waarde die hij in eerdere rekenslagen voor de betreffende variabele heeft berekend.
In het gegeven model zijn twee regels onvolledig.

3p **18** □ Geef de uitdrukkingen voor a_x en v.

Zelfs als het model volledig is ingevuld, loopt de computer bij de berekeningen vast, omdat hij variabelen tegenkomt die hij nog niet kent. Dat komt omdat de blokken A, B en C niet in de juiste volgorde staan.

2p **19** □ Leg uit in welke volgorde de blokken moeten staan.

- Model of the movement of a golf ball
  - Students have to finish the model: expressions for a and v and put blocks in right order

Brain and Education
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Present situation

- Level of implementation rather good

Key factors has been:

- **Consistent approach** for many years
- **Concerted action**: innovation, together with facilities, teacher training AND change of curriculum and examination

Coach Examples

- Measurement with sensors

1. Induction and ‘Walk a Graph’ (Physics/..)
2. Heartrate and Photosynthesis (Biology)
3. Titration (Chemistry)

- Modeling

1. Model titration
2. Parachute Jumper
3. Population

- Video

1. Own video
2. Baseball

Conclusions

- ICT enables and facilitates authentic, relevant and quality projects for highschool (and University) students.
- Students recognize these possibilities immediately and based on experience/preparation in previous lessons largely choose them for their projects.

Further

- Contact information:

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THANK YOU!