CoBaLT

Context-Based Learning and Transfer
in Science Education

I. Research background

The CoBaLT studies:

II. iMP: Mobile devices in physics/science education (Geneva)

III. The other studies:

– OSLeOs: Out-of School Learning Offers (St Gall)

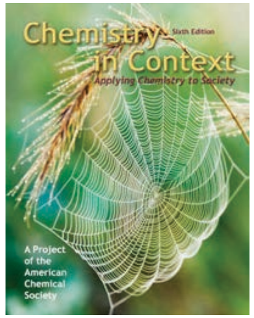
– Transfer (Lucerne)

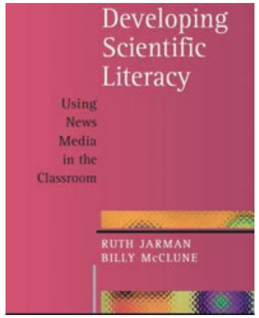
IV. Discussion, Perspectives

Guiding Idea: Context based Science Edcuation (CBSE)

I.

- context = real world connection
- essential for scientific / mathematical literacy
- examples
  - experiments, phenomena
  - newspaper stories, images
  - Out-of-School Learning Places

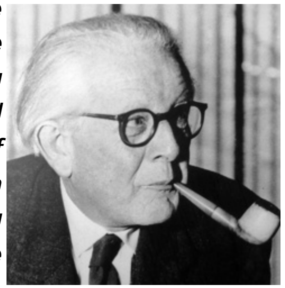




Authentic contexts: Spotlight I, with a Geneva taste

I.

When the school requires that the student's effort comes from the student himself rather than being imposed, and that intelligence should undertake authentic work instead of accepting predigested knowledge from outside, it is therefore simply asking that all of the laws of intelligence be respected



Piaget, J. (1971). The science of education and the psychology of the child. New York: Viking, (p.159).

Authentic contexts: Spotlight II: PISA

I.

In summary, PISA places most value on tasks that could be encountered in a variety of real-world situations and that have a context in which the use of mathematics to solve the problem would be authentic (OECD, 2006, 108)

- context = real world connection
- association context – authenticity (“authentic contexts”)
- essential for scientific / mathematical literacy
- note that even this “basic” understanding

is far from being trivial or educationally shallow
(even if more far reaching conceptualisations exist)

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I.

Guiding Idea: Context based Science Edcuation (CBSE)

- context = real world connection
- essential for scientific / mathematical literacy
- some effect sizes
  - large effects possible
  - both for affective and cognitive outcomes
  - not consistent, however (Bennett et al, 2007; Taasoobshirazi & Carr, 2008

CBSE approach	Effect Size (d)
STS (Science, Technology & Society approach)	
(1) attitudes (Yager & Weld, 1999)	0.69
(2) learning (")	1.52
biomedical contexts pre-post change, w vs. w/o (3) learning (Colicchia, 2002: Müller, 2016)	0.45 vs. – 0.52
Newspaper Story Problems / NSP (Kuhn, 2010)	
(4) motivation	> 1.7
(5) learning	> 0.9

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II.

Context 1:
iMobilePhysics (iMP)

(A. Gasparini, L. Darmendrail, AM; Geneva)

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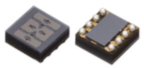
Use of Smartphones and Tablet-PCs as Experimental Tools

- Well-known usages of mobile phones:
  - Documentation & data storage
  - Cognitive tools (maps, calculators)
  - Communication
- Recent idea: Experimental tool



Using sensor data	*subject field*	*quantity*	*example*
Microphone (speaker)	acoustics	L [dB], f [Hz], I [W/m²]	beats,overtones

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II.

Advantageous factors for teaching

a) Simple apparatus replacing complex laboratory sets:
→ *quicker laboratory* sessions
→ *real time* data analysis devices
→ in many cases *more economic* than "traditional" lab systems

b) **Mobile and ubiquitous**
→ *real life exercises* (data ownership)
→ *interdisciplinarity* (data from physics/other subjects and occasions
→ stronger contextualisation, authenticity

c) **Wide-spread** (>80% teenagers own a smartphone)
→ pupils are *familiar* with the device as such (BYOD) ;
→ *informal learning* (!): show how to use devices
for *out-of classroom observations*
→ *combine* lab sessions / classroom exercises / homework tasks

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Research Approach

II.

Research questions: (very short formulation)

- ***Motivation***: Are pupils more motivated when working with smartphones instead of ‚traditional' equipment? Do they see a stronger link to lifeworld/experiment
- ***Learning/Understanding***: Do they learn better / more? What about more-than-short term effects? About transfer??
- Further dependent variables of interest: curiosity, episodic memory, …

Studies: Sec I, II (only short term), Tertiary/university

Methodology:

- quasi-experimental field studies with control (‚traditional equipment') and treatment (smartphone) groups,
- taking account of several covariates (gender, prior knowledge, …)
- repeated measures design
- method of analysis: ANCOVA, Regression Analysis

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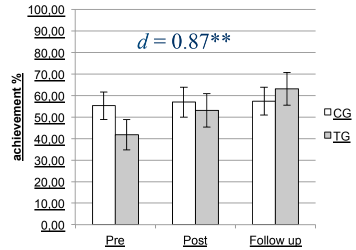
Study 1: Learning effects (Sec I)

time | control group (N=28) | treatment group (N=30)

2h -----PRE TEST----- -----INSTRUCTIONS-----

sign. positive effects on learning (Kuhn & Vogt, 2014)



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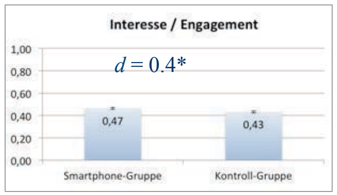
Study 2: Interest effects (Sec II)

time | control group (N=67) | treatment group (N=87)

1h -----PRE TEST-----

Study (Hochberg, 2016):
harmonic mechanical oscillations
conservative approach: smartphones, but in traditional experiments
short intervention (3h)

main results (no details)
sign. positive effects (small) on:
- curiosity (related to exp.)
- interest



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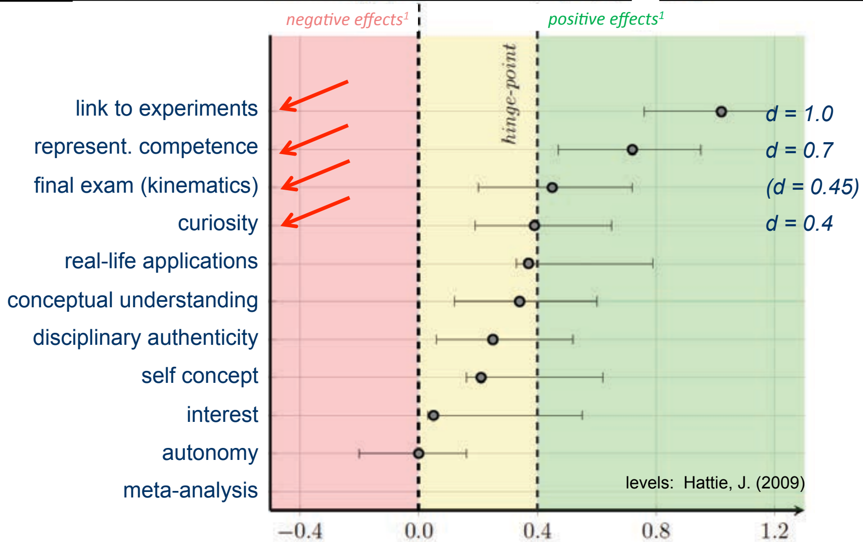
Learning and interest effects (University, physics undergraduates)



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New Study (COBALT): Learning and interest effects (Sec II) – Research Questions

II.

- Does the use of iMP lead to a better learning of
  - kinematics? (graph interpretation, linear motion)
  - dynamics? (force diagrams)
  - use of mathematics applied to physics (MAP) understanding? (vectors, proportionality, slope)

  for tertiary level: Klein, Kuhn, AM; Phys Rev – PER (2017)

- Does the use of iMP lead to a better motivation?
  - interest
  - authenticity, real-life connectionand/or interest?
  - curiosity
  - …

  for short term, restricted intervention: Hochberg, Kuhn, AM, 2017

- Secondary/potential research questions:
  - detrimental effects by distraction?
  - effects of homework integration (collect own data as homework + analysis in the classroom; eg. motion on a slide, a bike, a swing etc.)
  - …

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COBALT iMP Study: Outline

II.

- Sample : 2nd year high-school students (Geneva)
- Duration: one semester (≈ 16 weeks) sequence
- Topics : kinematics & dynamics curriculum
  - kinematics: 1D: ULM, UALM; 2D position, displacement vectors, average & instant velocity, speed, acceleration,
  - dynamics: Newton's laws, free fall
- Intervention (test group): 5 to 10 of iMP activities replacing standard exercises and/or laboratory sessions
- Instruments : affective and learning QCM based on standard tests (FCI, TUV, TUG), conventional test questions by teachers
- Co-factors: prior knowledge in physics/mathematics, gender

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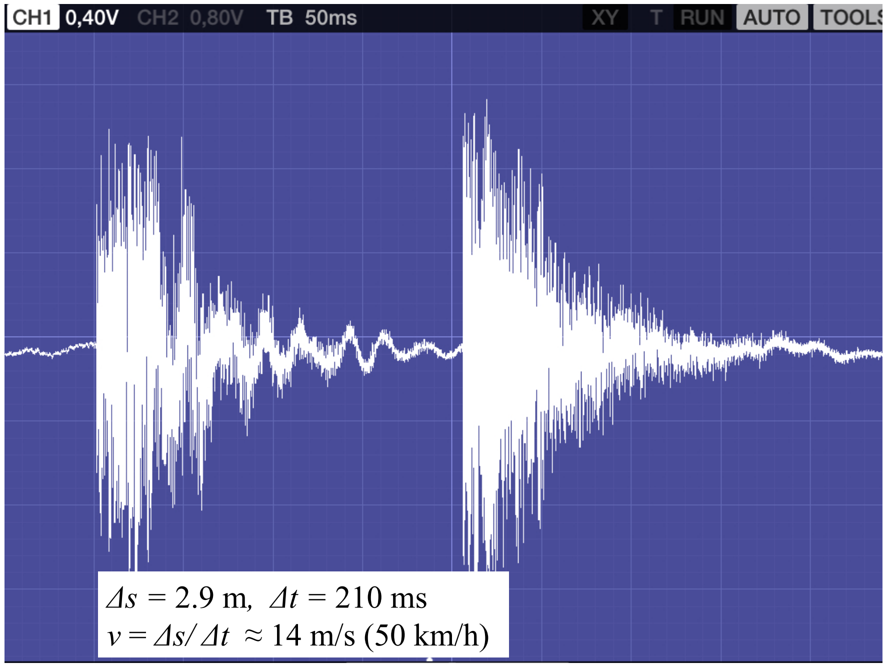
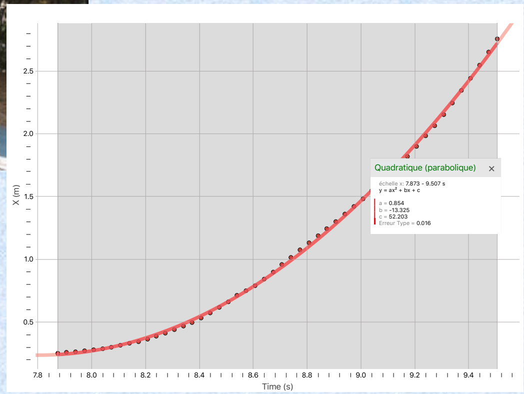
COBALT iMP Study: Pilot Phase (Fall 2018)

Week	Test group (N ≈ 15)	Control group (N ≈ 15)
1	pre-tests: prior motivation and knowledge/understanding	
2 to 5	iMP lab session + activity sheets	conventional lab sessions + activity sheets
6	short test	
7 to 10	iMP lab session + activity sheets	conventional lab sessions + activity sheets
11	short test	
12	iMP lab session + activity sheets	conventional lab sessions + activity sheets
13 and 14	exam session	
15 and 16	iMP lab session + activity sheets	conventional lab sessions + activity sheets
17	post-test: prior motivation and knowledge/understanding	



Example of activity – iMP application	PY2DF curriculum
Slide at the playground – VideoPhysics + Graphical	UALM (MRUA), inclined plane, slope, intercept, time equation, time diagram



can be adapted as
- introducing activity
- in-depth analysis

III.

Context 2:
Out-of-School Learning Offers (OSLeOs)

(D. Schriebl, N. Robin)

The Paul-Scherrer-Institut - an authentic research institution as home to the out-of-school learning offer iLAb

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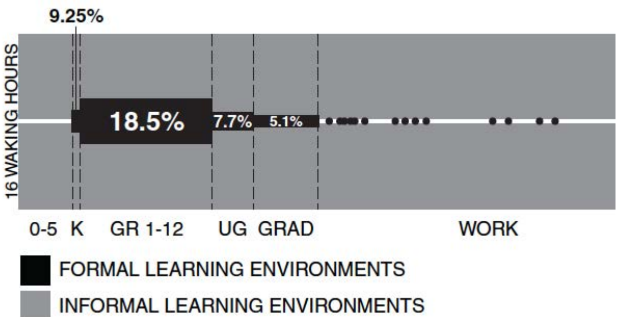
Informal (Science) Learning: Why bother at all?

III.

- *T* (available time)
- *N* (available participants): 1000s to 10000s
- *N* x *T*: very large ressouce for learning, complementary to school

Estimated fraction of time spent in and outside formal learning



National Research Council. (2009). Learning science in informal environments: People. places, and pursuits. Committee on Learning Science in Informal Environments, P. Bell, B. Lewenstein, A. W. Shouse, and M. A. Feder (Eds. (Washington, DC: The National Academies Press)

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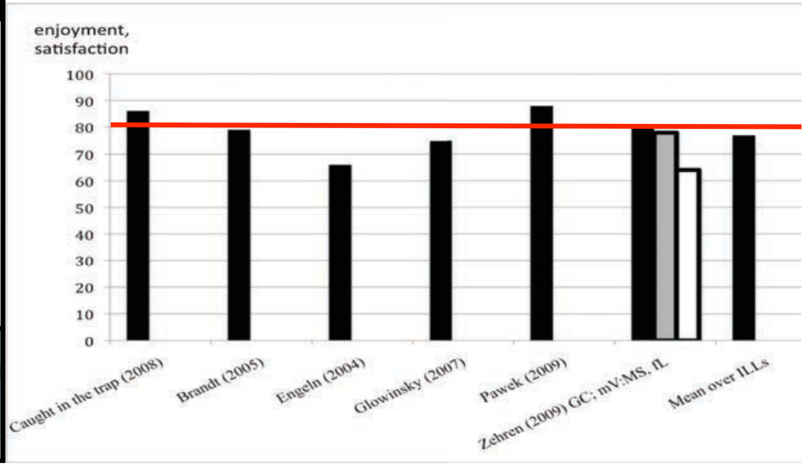
An encouraging message to begin with: enjoyment and satisfaction («fun»)

III.

- enjoyment and satisfaction of visit («fun»; short term)
- interactive learning labs (ILLs)
- …



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Out-of-school learning settings: some research results

III.

- too few studies, no meta-analysis

however, an approximate image becomes visible

- 1) "**fun factor**" (acceptance and popularity): good!
  - "was fun": ≥ 2/3 of participants ([Eng04]: 65%; [Paw09]: 88%)
  - "would enjoy another visit" ([Eng04]: 70%; [Paw09]: 90%).
  - [Eng04]: 5 labs, phy/che; [Paw09]: 2 labs, phy
- 2) **"gender gap":** immediate positive effect for girls > boys
  - science interest difference (girls vs. boys) decreasing from d (long term) = −0,85 to d (after visit) = −0,51 [Paw09, p. 122]
- 3) **"interest gap":** similarly immediate positive effect for low interest group > high interest group
  - science interest difference (initial low vs. high interest group) decreasing fror d (long term) = −2,33 to d (after visit) = −0,49 [Paw09, p. 122]

but

- **long term science interest**: no (or very weak) effects

III.

Transfer

(D. Gisin, D. Brovelli)

Inert Knowledge

III.

Above all things we must be aware of what I will call 'inert ideas' – that is to say, ideas that are merely received into the mind without being utilized, or tested, or thrown into fresh combinations.

Alfred North Whitehead: *The Aims of Education and Other Essays*. New York: The Free Press, 1929.

Some approaches to support transfer

III.

meta-analyses

- case comparisons: *d* = 0.5 (± 0.06)
  Alfiera et al (2013); across age and subjects; n = 336
- scaffolding: *d* = 0.46 (± 0.06)
  Hutchins et al. (2013), MA on error prevention, tertiary/vocational (computer use, math), n = 21
- cuing in multimedia learning: d = 0.3 (± 0.22)
  Xie et al (2017); mainly science/math, sec II/uni
- small-group learning: *d* = 0.3 (± 0.14)
  Pai et al. (2015), across age and subjects, n = 38
- schema activation with worked examples: *d* = 1.94 (± 0.56)
  Rayner et al. (2013); MA on transfer in mathematics, n = 9

some individual findings

- summarizing instructions + 1 vs. 2 examples: *d* = 0.65
  Gick & Holyoak (1983)
- with vs without self-explanations: *d* (near/far) = 0.72/0.68
  Atkinson et al (2003)
- worked example vs. inquiry web-based tasks: *d* = 0.5
- Lee et a. (2004)
- authentic contexts: *d (v/E)*= 0.96/1.31
  Kuhn (2010), Kuhn & Müller (2014)

The Bybee Levels: From (rote) reproduction to (advanced) transfer

III.

- written achievment test with 3 – 5 tasks
- PISA competence levels I – IV
  - **I**: reproduction of simple factual knowledge
  - **II**: simple application (mainly using layman concepts)
  - **III**: application (using scientific concepts for prediction & explanation)
  - **IV**: conceptual and procedural understanding
  - (**V**: conceptual and procedural understanding on high level)

  III/IV: transfert/application
- curricular & level validation through expert rating ($\kappa_C \geq 0.75$)

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Linking school and lifeworld for „classics" of mechanics teaching

IV.

- school

inclined plane

free fall

pendulum

$T = 2\pi\sqrt{\frac{l}{g}}$

rotation

$a = \frac{4\pi^2 r}{T^2}$

- lifeworld

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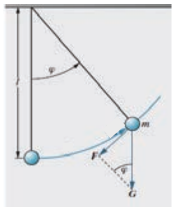
Next steps, things to come

IV.

- pilot study (2018, N ≈ 30): validation of intervention and instruments
- main study (2019, N ≈ 60): design, research questions as described
- first study on extended, systematic use in Sec II physics
- combining contexts: smartphones in out-of-school learning offers?
- transfer?
  - typology (what kinds of transfer)
    content (what) x context (when & where) Barnett & Ceci, 2002
  - classroom horizontal/vertical; classroom ⟷ lifeworld Ausubel, 2000; Renkl, 2004
  - representational transfer (coherence) Klein et al. (2017)
  - …



$$T = 2\pi\sqrt{\frac{l}{g}}$$

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