Information Technology (IT) to change biology teaching, or teaching IT-changed biology?

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BioED 08
Plan

- Context
- i-ICT : integration of ICT
- IT-Rich Biology
- Educational implications
- Designing IT- enhanced Biology teaching for responsible citizens
  - What litterature suggests
    - Selection : Authentic, Knowledge Building
  - Designing process
    - Examples
- A few design Rules
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Research context

- Biologist
- Biology educational software developer
  - Neuroodule, etc.
  - -> educational designer
- Lecturer teacher training :
  - ICT integration, educational sciences UniGE
  - -> Biology didactics, IUFE, UniGE
- Thesis research in Educational sciences TECFA LDES:
  - Biology evolution / IT-Enhanced biology teaching

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**IT and biology learning**

IT-induced change of science
-> IT enhanced Biology (BIST)
≠

**Didactic use of IT for teaching science**
-> iTIC
IT Education

- 3 levels
  - Train to use Computer
  - Integration in didactics iICT
  - Knowledge building IT enhanced tools

- iICT
  - Biology teaching with ICT
  - Biology IT induced change

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Educative Technologies?

Can technologies educate?
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Educative Technologies?

Can technologies éducate?
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Educational tools for teaching

- Presentation tools
  - Slides
  - Whiteboards
- Simulations
- ExAO (Faure-Vialle, B. 2001)
  - Experimenting (de Vecchi, 2006)
Etc.

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Science is a way of building knowledge

- **Biosciences** defining characteristics are:
  - (1) that all knowledge is related to observation or experiment,
  - (2) a family of methods and disciplines grouped around the investigation of life processes and the interrelationships of living organisms
  - (3) they exist in an environment of current hypotheses rather than certainty
  - (4) they include disciplines in which rapid change is happening
  - (5) they are essentially practical and experimental subjects »
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IT- enhanced Biology

- Biology is undergoing a paradigm change

- IT- enhanced Biology 4 aspects identified
  - Bioinformatics (Example)
  - GIS and other databases (Example)
  - Systems Biology and Simulations (Ex)
  - Knowledge building in an infodense world (Example)

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**Authentic Biology today?**

- In vivo (mid 20\textsuperscript{th})
- In vivo + In vitro (end 20\textsuperscript{th})
- In vivo + In vitro + In silico?
- IT - Enhanced Biology
  - Anecdotal evidence: most biologist spend near 70\% of their activity doing IT - Enhanced Biology
Biology itself changes

- We had searched for many years and found 1 human pheromone receptor. When the human genome became available,

In one week we found 110 new genes!


Then we went back to the bench to analyze their activity with classical tools

Complement not opposition

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Technology : virtual ?

- IT : virtual layer between reality and students ?
- Information IS what it’s about
- Protein,
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Massive amounts of Data

IT - caused avalanche of info
IT - enhanced tools to manage info
New tools, competencies, strategies

-> New teacher competencies

BIO2010 (2003). : Transforming Undergraduate Education for Future Research

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Complexity: popularize or empower?

- "The greatest intellectual sin that we educators commit is to oversimplify most ideas that we teach in order to make them more easily transmissible to learners. In addition to removing ideas from their natural contexts for teaching, we also strip ideas of their contextual cues and information and distill the idea to their "simplest" form so that students will more readily learn them.

- But what are they learning? That knowledge is divorced from reality, and that the world is a reliable and simple place. But the world is not a reliable and simple place, and ideas rely on the contexts they occur in for meaning." p.8
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**Authentic?**

  - Authentic data
    - Uniprot, Mapviewer, BookShelf
  - Authentic Tools
    - BLAST, Phyology, FaunaEuropea, SOPHY,
    - Freely available on the web
- Authentic Epistemology

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New BIST competencies

- Quantitative Biology
  - (algorithmic, Dynamical systems, differential, etc)
- IT tools:
  - Dbase, queries, BLAST, CLUSTALW, etc.
- Knowledge:
  - Dbases (NIH, SwissProt EMBL, TREMBL, GBIF, TOL, )
- Knowledge building strategies
Examples

- IBL for high school teaching
- Popularized science as a tool for knowledge building strategies
- Teacher training strategies
  - Teacher training Geneva
    - doiop.com/bist
  - ModulintégraTIC
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BIST

- How to teach students to build knowledge in an info-dense world?
  - Select, validate, build synthesis, produce valuable

- To practice true science i.e. work with uncertain knowledge (hypothesis)

- to improve knowledge in Biology?
Objectives

- **Learning Objectives**
  - Std or better achievement at exams.
  - Better *scientific thinking ≠* science of conclusions
  - Autonomy in learning: empower students

- **Research objectives**
  - Develop a teaching design for IT-enhanced Biology
  - Literature, experience -> design rules
    - Embed conjectures, test
    - Refine design rules
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IBL design

- Elicit questions
- Experiment, observe, read.
- Compose Q & A
- Present / Discuss
- Reframe

The crucial difference between current formulations of inquiry and the traditional "scientific method" is the explicit recognition that inquiry is cyclic and nonlinear.

Sandoval 2004 p. 216
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Teaching context

- Biology high school
- Geneva public schools
- Students 16-19 yrs
- Minor / Major
- Usual context, exams, etc

involvement vs distance : issue
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Conjectures 1/5

- Engage students in meaningful inquiry activity

  ->deep understanding.
Conjectures 2/5

- Iteratively writing a significant document (W2L)
  - Writing more than print to computer
- Writing (wiki) to build Knowledge in infodense environments
Conjectures 3/5

- Shared writing space (wiki) : idea confronting
  - (Socio-cognitive conflict (Astolfi & Develay, 2002; Hammer, 1996; Joshua & Dupin, 1993; W. A. Sandoval, 2003))
  - -> In-depth understanding, work on preconceptions
Conjectures 4/5

- Presenting current knowledge @ early stages
  - (Sandoval 2004)
- -> favor synthesis, interconnections
- -> learn to work with ideas "in an environment of current hypotheses rather than certainty".

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Conjectures 5/5… and more

- Teacher as tutor; knowledge authority found in experiment or resources.
  - (William A. Sandoval & Daniszewski, 2004)
  - develop scientific knowledge building, i.e."that all knowledge is related to observation or experiment".
  - validate ideas by their ability to explain data or stand up to criticism
Methods

- Design Based Research (DBR)
  - Global: *design* is the object.
  - Learning seen as system
  - Iterative design cycles.
  - Ethical: best design offered
  - Conjectures embedded tested, towards design rules

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Data

- Data sources
  - Wiki Data: all versions of text is recorded
  - Questionnaires
  - In-training teachers records
- Stratigraphic analysis
- Yearlong analysis
- Longitudinal analysis.
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Results: stratigraphic

Example: immunology

2 hours: 4 students new subject

- Question driven Inquiry
- Autonomy
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Results: stratigraphic

Example: immunology

- Mechanism questions
- Infodense management
- Question driven Inquiry
- Autonomy

3-4 weeks: 4 students 2 IBL cycles
End of year questionnaires

Students perceived

- Efficient learning method,
  - structuring, challenging, adequate to prepare for uni
- Autonomy, responsibility: pride.
- Mature view of resources,
  - defiant of affirmative «scientifically proven» info.
- Aware of power of writing to structure, build K.
- Aware of k. assessing potential of presentations
- Cooperation: Mixed feelings
- Workload!
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**Anecdote**

- En fait, (cette méthode) est proche de l'histoire de l'homme et du poisson. Si tu donnes un poisson un jour à une personne, il pourra manger qu'une fois alors que si tu lui apprends à pêcher... Personnellement, au collège, je préfère avoir notre poisson quotidien.
Results

- Student feed-back afterwards ([link])
- j'ai commencé l'université de St Gall ce semestre et la methode wiki est deja tres utile pour 4 grandes raisons:
  - 1° chaque matiere nous devons travailler en groupe.
  - 2° La deuxieme LWA qui nous apprend a travailler et apprendre de maniere scientifique. La methode wiki va exactement dans ce raisonnement soit de reduire au maximum l'apprentissage passif.
  - 3° travail / 2 mois. Ainsi, de savoir rapidement structurer un travail et savoir comment faire des recherches =atout
  - 4° j'ecris des questions bien precises -> etudiants plus avances dans le bachelor / programme de coaching.
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Some design rules 1

- *Matrioschka Russian doll* model

Select, choose Wade infodense

Questions

Meaningful Document

Student engagement

Wade infodense

Meaningful Document

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Some design rules

- Learn students strategies to manage complex information rather than popularize
- Structuring strategy: IBL
- T -> Coach
  - Question eliciting resources / activities.
  - Answer-finding resources / activities.
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Some design rules 3

- Embedding structuring control into the design
  - Empowers students.
  - Frees the teacher for high level interaction
- -> Formalizing design gives more freedom?
  - Example: define structure of document, of presentation, time control
Trade-offs

- Formal mastery of domain vs. developing student's ideas
- Document quality vs. quality of the learning supported by this document.
- Accessible, easy to understand resources vs. authentic resources.
- Popularizing science vs. empowering students to face complex information.
- Teacher authority vs. student empowerment.
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A few variables

- Document status re. student goal?
- Effective role of questions?
- Document ownership?
- Teacher’s perception of profession
  - Control?
  - Knowledge distribution
  - Scientific competence
  - …
Conclusions

- Evidence suggests
- Effective design for building k in infodense resources
- Design might empowers students: knowledge building
  - "No longer is information itself power; rather, power is gained from the ability to access the right information quickly." (NSF 2006)
  - And publish in relevant context.
- Design could develop better NOS.
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Questions -> discussion

- Science, school & uncertainty?
- Complexity / Pygmalion effect?
- Focus on student production?
- Teacher authority vs learners trust -> valid reference to learn from / with
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Refs 1/4


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Refs 2/4

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Refs 3/4

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Refs 4/4