Sustainable IBL inquiry-based science learning

Optimizing the student learning/teacher fatigue ratio.
Dr. François Lombard
Rationale

Epistemic complexity begin end year for one group (2008-2009)

Period of year

"Sept. 2008"  "Mar. 2009"

Item number in final document

0 20 40 60 80 100 120 140 160 180 200

Elaborated Explanations (EE)

Unelaborated Explanations (UE)

Elaborated Facts (EF)

Unelaborated Facts (UF)

"Sept. 2008"  "Mar. 2009"

19 17

36 77

32 40

40 40
D'un individu à l'autre, les gènes diffèrent de 12 %

Nous serions plus différents qu'on ne le croyait jusqu'à présent: 3 000 de nos gènes, soit près de 12% d'entre eux, ont subi des modifications au cours de l'évolution, et nous différencient aujourd'hui les uns des autres au sein de l'espèce humaine. En cause: des duplications, délétions et insertions de segments d'ADN, qui peuvent influencer l'activité des gènes. Une équipe de chercheurs a inspecté et dénombré, via une nouvelle technologie de scanner, ces variations dans le génome de 270 volontaires provenant d'Europe, d'Afrique et d'Asie. Verdict: 1 447 variations, dont certaines sont déjà connues pour être liées aux maladies d'Alzheimer et de Parkinson, tandis que d'autres influenceraient la sensibilité au virus HIV-1 ou seraient impliquées dans certaines formes de daltonisme. Une découverte qui expliquerait les différences de sensibilité à l'environnement, aux médicaments et aux maladies.

> 3 000 de nos gènes nous différencient au sein de notre espèce.
Scientific understanding

- Justified (Toulmin, 1958)
  - Based on experimental data
  - Aware of methods models and assumptions
  - Debated with community
    - Subjected to peer review
- “Thickness” of scientific understanding
- Understanding is autonomous
  - To understand science ≠ to know about science
- Autonomous justification
Justification in science and in school

• **Experiment** – publication - discussion (social confrontation)

• Science – Nature -> proxy for experiment

• Textbook : proxy for proxy for experiment...

• Teacher handout : proxy for proxy for proxy for experiment ...

**Didactical transposition** (Chevallard, 1991) Loss of methods, uncertainty, limits, discussion, -> definitive visually striking testable conclusion

-> Confront students to **authentic** resources
IBL : focus on *learning*

« In other lectures, you wait a few moments and the teacher gives the answer, so you write it down and don’t do the effort of thinking, and finally you must redo all the work of understanding at home. ”

Student in questionnaire end of year 2006

Inquiry ...a sharing of responsibility towards knowledge between the teacher and the students leaving important parts of responsibility to the students  

• Don’t teach, because science is not learning it, and it doesn’t work.

• Manage interactions between learners and resources.

[Image of a teacher and students with a cartoon character.]
Most critical design elements

• 1 ° Authority separation
  – Scientific authority from experiment or authentic resources
    • Wean students from T authority in justification
  – Firm but encouraging pedagogical authority : T
  – Guide by negotiating questions
Which $Q^\circ$ is

– Discuss with neighbor (1')

• 1) What is the universal donor blood group?

• 2) Why is mixing same bloods different when giving udp and receiving udp?

– Vote 1 or 2

Janeway, fig A9
Good scientific question?

- Biology main question
  - Ontological, Descriptive -> 1950
  - Underlying
Implicit question in title: "humoral immunity"

What causes antibody production and how does it happen?

What is humoral immunity?

What are B lymphocytes, and what is their role?

What is the use of antibodies, how do they function?

Can B lymphocytes function without T lymphocytes?

Memory cells and plasmocytes?

What is immune memory?

What is clonal selection?

What are lymphokines?
Most critical design elements

• 2° Student *responsibility* (towards peers) of developing a share of knowledge
• Learners « own » Q° (want to / understand)
• Chapter divided into groups
• Co-writing of critical document for peers to prepare exams
• Peer presentations – early
• Commitment to knowledge improvement
The design we analyzed

I Elicit questions
Questions: Distribute

II Search-synthesize-write

III Present
Redefine Q°

IV Institutionnalize
assess

Bound / reframe concept

Revise - deepen concept

Questions number and relevance increases

Questions refined

write understanding of concept

Revise - deepen concept

Synthesize concept

1 group

other groups

Wiki page

Wiki page

Wiki page

Wiki page

Wiki page

Wiki page
Question-centered and Q°-driven

– RD8: Questions negotiated in reference to the objectives drive investigation
  • Supervise Q° ~ as conceptual attractors
  • Question refinement : vague Q° -> good Q°

– RD10: Responses should address the concept defined by the question: conceptual coherence of questions and corresponding answers
  • Allows guidance
  • Prevents “Google - drowning “
Critical variable for guiding

• Good scientific answer?

  – Facts simple elaborated explanations simple elaborated

• Quality of answer
  – Content independent
  – Relevant (Morange 2003)

Simple facts... to...

Elaborated explanations

• Reasons, relationships, or mechanisms elaborated.

How are the antigen-specific type of lymphocytes activated by cytokines, i.e. what is double activation?

Double activation. Certain T8 responses require T4 : T8 recognizing antigens on weakly co-stimulatory cells can only be activated in presence of T4 linked to the same APC. This happens mainly by way of a T4 recognizing an antigen on an activated APC inducing high levels of co-stimulatory activity on the APC, which in turn activates T8 to produce its own IL-2. *(Translated from french by author)*
Teacher intervention -> phase change

Epistemic complexity over investigation time for one group’s text (end 2006)

Inquiry progression: version number

Item count

0 10 20 30 40 50 60 70

0 10 20 30 40 50 60 70 80

Unelaborated facts (UF) Elaborated facts (EF) Unelaborated Explanations (UE) Elaborated Explanations (EE)
Question negotiation

• Questions mainly arise from resources and activities
• Questions are revised during presentations
• Questions are supervised by T
• Q° framed by Objectives, guided by paradigm - resources
Teacher centered view

RDA1: Encourage student’s responsibility towards peers of a share of knowledge

Community of learners

Involvement in learning

Scientific understanding:
- autonomous justification
- conceptual refinement within paradigm
- tested by socio-cognitive confrontation

RDA2: Develop shared goal of deepening conceptual biology knowledge

Cooperative Structure

RDA4: Progressively devolve validation to learners

RD5: Expose to peer ideas during elaboration encourage socio-cognitive confrontation

RD6: Let the "good questions" emerge from confrontations with authentic resources in the paradigm; create this confrontation if necessary

Confrontation to authentic resources from paradigm
(Kuhn, 1972; F. Lomberg, 2010; Sandoval, 2003b; The Cognition and Technology Group at Vanderbilt, 1990)

RDA3: Transfer to resources validation of scientific knowledge, maintain educational authority

Conceptual deepening within paradigm of biology

Autonomous scientific justification
Student- Teacher share common goal of conceptual knowledge deepening

- Assessment, feedback focused on improvement:
  - RD23: Teacher feedback encourages cognitive conflicts by

Comment un gène peut-il être régulé?

La régulation des gènes se passe sur l'ADN. plus haut vous dites que cela peut se passer ailleurs... précisez que vous étudiez ce cas bien documenté. En effet, il y a tout d'abord une lutte entre activateurs et répresseur pour savoir je ne pense pas que ces molécules savent quoi que ce soit... on préfère un langage objectif en science. Si le gène sera inhibé ou activé. Certains répresseurs empêche l'activation de l'ADN polymérase et d'autres empêche la liaisons des activateurs à l'ADN ce qui inhibe le processus de la transcription. Si le régulateur de protéine ne vient pas se lier avec l'ADN ici il manque un bout de phrase... polymérase alors la protéine ne se fera pas au final. Dans construc

- Coopera1
  - Student
  - RD5: Encour
Focus on student knowledge improvement

• Tolerate imperfection, but progressively develop quality of explanation

• Assess for progress not moral values
  – Allow revision
What guidance?

- Firm, encouraging pedagogical authority allows student autonomy
  - RD27: Educational authority is largely embedded in the structure of the design thus confirming the freedom of students within that framework and frees the teacher for conceptual control and relationship management

Vous êtes-vous sentis autonomes mais suffisamment encadré-e (à la fin) ?
Je me suis senti désorienté-e =1 -> L'autonomie me convenait bien =4

Average 4 years = 3.41 out of 4  sd.= 0.69  N = 22

field and the emergence of epistemic complexity
We love Biologie!
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Thankyou for
For your attention

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Sample

- 19 year old final higher secondary school students N ~ 98
- Wiki records $10^6$ words
  - Questionnaires
    - End of year
    - 1 year later at university
- 2002-2014
- Full year inquiry
- 12-16 students / 4 groups
- Normal time, curriculum, exams
Truth in science?

- Science is models
  - Hypothetical
  - Modifiable
  - Appropriate for certain problems
  - Limited scope (Martinand, 1996)

- Models are accepted for their capacity to explain data ≠ truth
Didactical transposition

Confront students to authentic resources