No magic wand for teaching physics

Diversity of pedagogical tools: a need
Overview

- Innovative teaching methods?
- Diversity, a must: examples
- Perspectives and conclusions
Université de Savoie: Presentation

• located in Chambéry and Annecy (French Alps)
• small to average size: 13000 students
• attending physics classes:
  • ~150 (1st yr), ~120 (2d yr),
  • ~20 (3rd yr), ~20 (Master), ~10 PhD
• physics department staff:
  • ~20 « enseignants-chercheurs »
    and teachers
  • ~50 researchers, 3 labs
Changes...

- **Social**
  - Technology (Computers, Phones, Internet…)
  - Communication (SMS, Social web…)

- **Organisational**
  - Licence / Master’s / Doctorate (LMD)

- **Need for a change in pedagogy**
  - Can we stay with the traditional lecturing/training system?
  - « Teaching, Teaching and Understanding Understanding » video

- **This is the right time to change!**
… with difficulties

- We are primarily physicists, with a lot of good will…
- A lot of theoretical and practical tools were developed recently:
  - Audience response devices (Clickers), Online learning platforms
  - Peer instruction, Flipped learning, Hybrid teaching
  - Interactive learning strategies, Constructive alignment
  - « Active » pedagogies
- But…
  - which ones to use, understand, study ?
  - in a team ? alone ?
Theory and interpretation

- John Biggs (1996): 3 levels of teaching

**What students are**
Level 1
« There are good and bad students »

**What teachers do**
Level 2
« A good class makes students understand »

**What students do**
Level 3
« What students do matches the intended learning outcomes of the class (and assessments) »
Theory and interpretation

- John Biggs (1996): 3 levels of teaching
  - Level 1: « teacher-centric »
    - « There are good and bad students »
  - Level 2: « teacher-centric »
    - « A good class makes students understand »
  - Level 3: « student-centric »
    - « What students do matches the intended learning outcomes of the class (and assessments) »

- Marcel Lebrun (UCLouvain): diversity of methods and tools

Personal interpretation
- There are no universal tools or methods
- Implement a « Level 3 » teaching
- Needs tools for each specific course/teacher
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Strategy

- At the beginning, like a brainstorming (or « pedagostorming » ?)

- Several teachers tried:
  - Videos of physics courses
  - Online interactive exercises
  - Tutorials in small groups
  - Use of audience response devices
  - Assessment of learning gains via concept inventories

- Creation of a pedagogical and technical coordination group
Enhanced videos of physics courses

- R. Taillet (and D. Buskulic for E&M)
- 105 x 1.3 hrs lessons, in French
- 9 different courses:
  - Mechanics,
  - Electromagnetism, Geometrical optics, Physical optics,
  - Introduction to Special Relativity, Introduction to General Relativity,
  - History of science,
  - Thermodynamics,
  - Electrostatics and Magnetostatics
- 180 000 complete downloads in 2 years
Enhanced videos of physics courses

- Use:
  - Exam preparation, discovery (pensioners, adults returning to university, curiosity), complement to other courses, late arrival during the year
- Cost: 300-400 hrs of work
Tutorials in small groups

- Tutorials in elementary Mechanics, Optics
- Small groups of 4-5 students, « guide on the side teacher »
- Level:
  - 1st year, 3rd year Licence
  - 1st year Master’s (preparatory homework by a member of the group)
- Each group solves a problem on a blackboard
- Each student in turn has a role:
  - scribe, writer on the blackboard, others participating in the reflexion
- Licence 1, Master’s 1: works well;
- Licence 3 : difficult, students do not know how to get organized
  - Tentative interpretation:
    - those students never had anything else than the « standard » system
Audience Response Devices

- Many types of peer instruction, use of the « original »
- For each lesson, four or five times:
  - Instructor asks a question
  - Students answer (vote)
  - Instructor shows statistics of the class
  - Students reflect, talking with their peers
  - Students vote again
  - Instructor decides what kind of (mis)conceptions he can comment on
Audience Response Devices

- Effectiveness demonstrated by research
- Used in a few courses in our university:
  - Chemistry, Mechanics, Electricity and Magnetism
  - Many more to come
- We convinced ourselves by experimenting!
- Easy to implement, doesn’t change much the organisation
  - Well, at the beginning…
- Students active and pleasantly surprised
- Strong incentive to re-think a course
  - Good introduction to flipped classroom
What about measuring the effectiveness of our teaching?

Inventories: assess student learning gains

- Force Concept Inventory (FCI)
- Test on 60 students this year
- Test before the course and after the end
- Still rough analysis, no quantitative results yet
- Intends to continue use of FCI, as well as CSEM or BEMA
- **WIMS** = Web Interactive Multipurpose Server
  - teaching platform
  - interactive resources
  - tools to build resources

- Difference with other platforms ?…
WIMS Philosophy

- Platform created by a network of teachers
  - for the teachers (and students…)
  - maths, physics, chemistry, english, biology, french, electricity, electronics…
  - from elementary school to university
- open access, open source
- create exercises on any WIMS platform
- share exercises with the community
- exercises with random data and automatic correction
WIMS : pedagogical resources

- Interactive exercises
  - with random data...
  - ... and automatic correction
  - various answer types
    - choice (buttons, pictures,...), association (drag & drop)
    - numerical answer, formal (analysis of the answer)
    - clic on image, clic on 3D object (jSMol)
    - ...
  - link to external software :
    - povray, maxima, pari, octave, JSmol, JSXGraph...
WIMS: pedagogical resources

- Interactive exercises with random data
- and automatic correction
- Various answer types: choice (buttons, pictures, ...), association (drag & drop), numerical answer, formal (analysis of the answer), click on image, click on 3D object (JSmol), ... 
- Link to external software: povray, maxima, pari, octave, JSmol, JSXGraph...
Demonstration
WIMS use

- Entry level tests (Licence 1st yr)
- Tutorial preparation / followup
- Assessment and self-assessment
- Exams
- in maths, physics, chemistry (in Univ. de Savoie)
Results and students feedback

- Videos
  - Very positive feedback, from all over the world

- Tutorials in small groups
  - 80% of students clearly more active, find it more pleasant
  - Students would like a written solution, not very practical

- Clickers
  - Very positive feedback, students more active, attentive and concerned during the class
  - Still need to assess effectiveness with inventories

- WIMS
  - Spares time during tutorials
  - Example, diff. equations: "We really understood thanks to the WIMS exercises"
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Some thoughts

- Started as separate efforts
  - Each teacher developed the tools/methods that he felt were good
- Common desire: make the students progress
- Whatever the tools, will be able to reuse them
- Need enough different tools to align
  - teachers way of doing class
  - students way of learning
- Coordination essential but comes a little bit after…
What about the Master’s level?

- Innovative pedagogical tools apparently less relevant
  - students have grown up, more mature
  - have been selected
  - are already active in learning
- In a few years, students used to those tools
  - it will become relevant!
  - Pedagogical tools built now useful even at master’s level
- Specific case of the Master’s in education
Conclusions

- Trying to develop
  - a « student centric » teaching
  - a set of tools diverse enough

- Different efforts:
  - Videos of physics courses, WIMS online interactive exercises, tutorials in small groups, audience response devices, concept inventories

- Coordination to spread the best practices

- This is not the end
  - Next year: test a flipped classroom for some subjects