

Experimentation of a
new pedagogical method in
1st year's teachings of physics

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Outline

- Problems for students and teachers
- A « new » pedagogical method
- Results of the 1st year experimentation

Problems for students and teachers

- knowledge : wide but superficial
- technical ability (calculus) : almost inexistant
- expermental ability : low
- working methods : inexistant for most of them
- maturity : inexistant for most of them



Student paradox

Ambition/pretension

opposed to

working methods/ability/motivations

Reform of the secondary educational system

- « New students » arrived in 2013
- most problems are reinforced :
 - formation in physics \longleftrightarrow scientific culture
(bac exam \longleftrightarrow almost text explanation !)
 - approach more important than contents
 - calculus ability : strongly decreased/disappeared
- but :
 - additional pédagogique methods (more experimental, scientific approach with projects and stages ...)

Net advantage : students are ready for active learning !

Problems for students and teachers

⇒ **Teacher/System paradox**

C Short term solution : **program reduction !**

Problem : 2nd year (and higher) adaptation

Solution : student autonomy and maturity (book reading) !

Ti

+ **Heterogeneity problem**

Experimentation of **carrot and stick techniques !**

Additional seances for best students on more difficult problems or more fondamentale aspects. (Dispense of certain seances but they even came !)

Traditional education at university

- Lecture in amphithéâtre (lecture hall) :
5-10% follow efficiently
>90% sleep, discuss, play w. phones or don't come

Time is wasted !

- recitation section (Travaux Dirigés) :
Students wait for the detailed answers of the required exercises. Don't work the problems alone, at home or in classroom.

Time is wasted !

⇒ **Students are passive**

- 2 exams : half semester + final (even with CC)

⇒ **50-60 % of students fail**

Solutions for teachers

- Make research and minimise/forget teachings!
- Become blind and teach for 10%
- Fall into depression !
- Stop teachings and make another job !
 - Change your practice and make active learning

Experimental learning / Project

- Experimental practice (Travaux Pratiques) :
1/6 of the time is devoted to experimentations.
There are difficulties but nothing new !
Various methods are experimented... see Morizot talk
- Project is a formation unit (UE : 6 ects)

In the following we insist on methods used to develop a deep understanding of the discipline through physical reasoning and problem solving abilities (as required for national engineer schools competition...)

ie the «theoretical» aspects of physics (modelisations, laws, theories, mathematics, approximations ...) used to describe physical phenomena which pose the more severe problems today

A «new» pedagogical method : frame

- Mixture between Problem Based Learning (APP) and Peer Instruction
- Applied to 5 classes of 24 students in 1st year engineer school Polytech (PEIP@AMU). 10 teachers have played the game. The 120 students are selected (mentions «very-good» and «good» at bac, notes >14/20 in «terminale»).
- Teaching units (UE) : (semester = 12 weeks)
 - Mechanics (S1 + S2) (3h/week)
 - Optics (geometric, S1) (2h/week)
 - Electricity (S2) (2h/week)

A «new» pedagogical method : principles

➤ No lecture ! Stud. work at home individually

→ Reference book : Young&Freedman «University Physics»

Pedagogical and easy calculus (Hecht for english rebarbatives)

→ Teachers book (handout/polycopié) :

Complementary to reference book :

→ optics : historical/pragmatic approach see talk of Olivier MORIZOT

→ mechanics and electricity : applications and fundamental aspects of the new ideas introduced + initiation to physical problem resolution (any calculation/demonstration is a «course exercise» with extremely detailed solution).

➤ No correction of exercises/problems !

Work in classroom in groups of 6 students

Traditional recitation sections \longleftrightarrow tutorials

➤ Students work in groups

each student has a role (leader, scribe, secretary ...)

timetable should be respected

Tutor answers questions with questions, and is a guide towards the good way

➤ If necessary :

courses recall of essential points

corrections for the most difficult problems

➤ **High frequency evaluation** : without =>
~ each seance : no work at all

→ 10-15' home work evaluation (individual)

* MCQ when new chapter (knowl. definitions, easy application)
using «vote materials» («clickers») for instantaneous
evaluation of the results (=> teacher know what to do ...)

* small exam (interro.) (simple exercises) on paper

→ **report of the preceding seance** (neat writing of the
exercises/problems) (=> teacher control knowledge acquisition)

when time allows : oral examination

→ **beginning**: best students present an abstract of the course

→ **end** : weak students present the results of the group work
but the note is for the whole group !

Notation :

- one note for all these evaluations during seance (NTD)
- 2 partial exams (1h30, weeks 5 and 10) (NDS_{1,2})
- final exam (3h), double coefficient (NE)

$$NF = NTD + NDS_1 + NDS_2 + 2*NE$$

This method allows to address the «student paradox» :

Passivity => failure is guaranteed !

Clear contract : be active and take control of your own learning

“ Less teaching yields better learning ” (E. Milgrom)

but collaborative work in groups is essential

A «new» pedagogical method : details

Seance plan :

➤ **Homework (2 - 4 h) :** individually is preferred but not mandatory

- read + understand chapter/sections of the reference book
- be able to make application exercises of reference book
- read teacher book and understand course exercises/demo.
- preparation of exercises/problems of the next seance

➤ **Seance (optics/electricity 2h, mechanics 3h) :**

- initial evaluation : 10'-15' individual
- group works : 1h-2h collective
- final evaluation (oral) : 20'-1h (when necessary or cancelled when good works by all the groups) individual or collective

Working in groups

- **favorise individual learning of the discipline**
 - better preparation of the understanding
 - confront different point of view
 - group emulation (and student auto-regulation)
 - necessity to explain own ideas and to communicate to others (basis of peer instruction)
- **developp general abilities :**
 - critical reasoning
 - logical and analytical approaches of the problem
 - decision taking
 - auto-evaluation
 - communication
 - conflict resolution

Group timetable

- 2' : group organisation : roles distribution
- 1' - 5' : Read : know what the exercise/problem is
- 5' : Analyse : understand and clarify the problem
- 20'(ex)-1h(pb) : Set and Solve : how to treat the problem
 - * what we know and don't know
 - * analogies with solved problems
 - * assumptions list and simplification of the problem
 - * solve if all tools are in hand or :
 - establish learning objectives : what should be learned
 - establish an action plan : tasks list for next seance
- 1' - 5' : Evaluate the solution
- 1' - 5' : group bilan

Repeat for each ex/pb to
be treated in one seance



Group roles

Indispensable to optimize group efficiency

- **Leader** : organize the discussions : speech distribution, ideas clarification and synthesis, motive everybody to participate, ...
- **Scribe** : manage the paper board / memory of the group : write all the ideas, synthesis of the informations, ...
- **Steward** : logistic and time keeper
- **Secretary** : write the synthesis of the group results : transmit the first draft of the report to every members
- **Participants** : control group dynamics, make dimensionnal analysis and numerical applications, ...

Discipline understanding and Problem solving progressions

To get a deep understanding of the discipline

- **read books** : ideas and fundamental concepts are presented pedagogically along with their applications in every day life or in other branches of physics, or sciences in general
- **solve physical problems** to increase understanding and technical/calculus abilities. Difficulties are progressive :
 - **easy applications of concepts** (physical and mathematical)
 - **exercices** (1 concept) OR **problems** (several concepts linked up) **with detailed succession of questions** (reasoning is alleged)
 - **«open» problems** where physical reasoning and scientific maturity are required

Results

- Students with solid knowledge/abilities : 10% → 50% !!!
in spite of a «lower» initial level («due to secondary school reform»)
and more difficult exams (partial and final)
score final exam (average) : 7.3/20 → 8.9/20
score teaching unit (average) : 8.8/20 → 10.3/20
- 10% best students : 12-14/20 → 16-19/20
- Exams are more difficult : synthesis problems like 10 years ago!
- Student evaluation of the pedagogical method :
positive evaluation : S1=58% → S2=72%
best students are extremely positive ! (negative eval. = failed stud.)
- some groups became teams ! Students continue to work together in
other disciplines ... more and more colleagues discuss the method ...
*Incredible: best students said « For the first time we've worked harder in physics than
in mathematics » ...with happiness and pride !*

Difficulties

Results are encouraging but many difficulties are present

→ Students need 1 month to understand the necessity to work (hard) and that exigences are far more severe than at high school !
(eg major has begun with 4/20 and has finished with 18,5/20)

→ group emulation works if more than 3 students (among 6) play the game
1 or 2 groups (among 4) per class had a weak emulation ...

Rebarbative students = students with big difficulties (future failed) or good students hating physics (worse case, difficult to manage because they bring motivated students downwards ...)

→ when teacher/tutor is not convinced, student motivation decreases and difficulties increase ...

→ if (partial) exam is too easy and students get high notes, they stop working ! If teacher relax pressure, they stop working...

Projects for next year(s)

- Videos of lectures
- Web interactive exercises with automatic corrections (eg WIMS)