Introducing Interactive Learning into French University Physics Classrooms

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Sabbatical at UPMC

On a sabbatical at UPMC in Spring 2012:

- Worked at the Université de Pierre et Marie Curie (UPMC) in Paris to help introduce interactive learning into their physics classrooms
- Two main interactive learning strategies were used
  - Think-Pair-Share questions aka Peer Instruction
  - University of Washington Tutorials
- Collected data on the effectiveness of those interactive learning strategies in a French university
Participants and collaborators

Participating Faculty at UPMC
- Michael Joyce*
- Romain Bernard
- Hélène Roussel
- William Sacks
- Benoit Semelin
- Hélène Vignolles*
- Pascal Viot

*Collaborators on research project

Other Collaborators
- David Consiglio, Bryn Mawr College

Why?

- Over decades of research in the US, it has been shown that interactive learning strategies can improve student learning compared to lecture alone.
Study at Harvard showed improvements

<table>
<thead>
<tr>
<th>Year</th>
<th>Normalized Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.25</td>
</tr>
<tr>
<td>1991</td>
<td>0.49</td>
</tr>
<tr>
<td>1993</td>
<td>0.55</td>
</tr>
<tr>
<td>1994</td>
<td>0.59</td>
</tr>
<tr>
<td>1995</td>
<td>0.64</td>
</tr>
<tr>
<td>1996</td>
<td>0.68</td>
</tr>
<tr>
<td>1997</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Continued use led to higher gains

\[ g > 0.7 \quad \text{"High"} \]

\[ g = \frac{\text{post} \% - \text{pre} \%}{100\% - \text{pre} \%} \]

\[ 0.3 < g < 0.7 \quad \text{"Medium"} \]

\[ g < 0.3 \quad \text{"Low"} \]

red = traditional  green = interactive engagement

Questions to answer

- Could interactive learning work in France?
  - Would the use of interactive learning strategies lead to higher learning gains?
  - Would it be accepted by students?
  - Would it be accepted by instructors?
Challenges

- France has a different education system
  - Students select their “major” at a much earlier age (high school)
  - The system is traditionally more rigid
  - Students are used to passive note-taking in lecture-only classes
  - Instructors can be more conservative than the students
Challenges

No clickers!

“This is the land of Descartes”
- UPMC instructor
Project design

- October 2011 – I gave a talk at UPMC for faculty interested in implementing interactive learning in their classrooms
- January 2012 – I led two workshops at UPMC for faculty on interactive learning
- Spring 2012 – Faculty at UPMC implemented interactive learning in their classrooms
- Spring 2012 – In two classes, LP112 (second semester mechanics) and LP203/LE205/LP207 (second year E&M), some sections used interactive learning and others didn’t
- Spring 2012 – We collected data on student learning in these classes (FCI, CSEM, common exam questions), as well as on student and faculty attitudes towards these changes
2 workshops for faculty

- One workshop on using Think-Pair-Share (TPS) questioning in the Lecture Hall (Amphi)
- A second workshop on the use of Tutorials in recitations (TD)

Practicing Think-Pair-Share

Working on a Tutorial
Inattentive? Think again. These students are working.
LP112 – second semester mechanics

LP112
N=476

PCME21
N=83
TD21.1
TD21.2
TD21.3

PCME22
N=82
TD22.1
TD22.2

PCME23+
N=115

MIME21
N=107

MIME22+
N=89

Interactive

Traditional
Data collected

• FCI* pre- and post-instruction
• Common final exam
  – One conceptual question
  – Two traditional, problem-solving questions
• Student demographics
• Student feedback survey
• Instructor feedback survey

*FCI stands for “Force Concept Inventory”, a research-validated concept inventory on the topics of Newton’s Laws
Amphi A2 – UPMC
Amphi A2 – UPMC
A metal ball is dropped and hits the earth. When the ball has penetrated the earth but has not stopped, what is the relationship between the force $F_{BG}$ exerted on the ball by the earth and the force $F_{GB}$ exerted on the earth by the ball?

**On the ball** On the earth

A. $F_{BG} > F_{GB}$
B. $F_{BG} < F_{GB}$
C. $F_{BG} = F_{GB}$
D. There is not enough information given

LP112 - Dynamique des Systèmes
<table>
<thead>
<tr>
<th>Week of</th>
<th>Tutorial</th>
<th>Pretest</th>
<th>Homework Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep 26th</td>
<td>Acceleration in one dimension</td>
<td>On: Wed, Sep 28 10:20 am Off: Thu, Sep 29 9:20 am</td>
<td>N/A Problems: N/A Assignment numbers correspond to problem numbers, not page numbers.</td>
</tr>
<tr>
<td>Oct 3rd</td>
<td>Conservation of momentum in one dimension</td>
<td>On: Wed, Oct 5 10:30 am Off: Thu, Oct 6 9:20 am</td>
<td>Acceleration in one dimension Problems: 3, 4, 5, &amp; 6</td>
</tr>
<tr>
<td>Oct 10th</td>
<td>Work and changes in kinetic energy</td>
<td>On: Wed, Oct 12 10:30 am Off: Thu, Oct 13 9:20 am</td>
<td>Conservation of momentum in one dimension Problems: 1, 2, 4 &amp; 5</td>
</tr>
<tr>
<td>Nov 7th</td>
<td>Motion in two-dimensions</td>
<td>On: Wed, Nov 9 10:30 am Off: Thu, Nov 10 9:20 am</td>
<td>Conservation of angular momentum Problems: 1, 2, 3 &amp; 5</td>
</tr>
<tr>
<td>Nov 14th</td>
<td>Newton' second and third laws</td>
<td>On: Wed, Nov 16 10:30 am Off: Thu, Nov 17 9:20 am</td>
<td>Motion in two-dimensions Problems: 1, 2, 4, 5, 6, &amp; 7</td>
</tr>
<tr>
<td>Nov 28th</td>
<td>Relative Motion</td>
<td>On: Wed, Nov 30 10:30 am Off: Thu, Dec 1 9:20 am</td>
<td>Newton' second and third laws Problems: 1, 2, 4 &amp; 5</td>
</tr>
<tr>
<td>Dec 5th</td>
<td>Dynamics of rigid bodies</td>
<td>On: Wed, Dec 7 10:30 am Off: Thu, Dec 8 9:20 am</td>
<td>Relative Motion Problems: All problems</td>
</tr>
</tbody>
</table>
Sample from a Mechanics Tutorial

ROTATIONAL MOTION

I. Motion with constant angular velocity

A wheel is spinning counterclockwise at a constant rate about a fixed axis. The diagram at right represents a snapshot of the wheel at one instant in time.

A. Draw arrows on the diagram to represent the direction of the velocity for each of the points A, B, and C at the instant shown. Explain your reasoning.

Is the time taken by points B and C to move through one complete circle greater than, less than, or equal to the time taken by point A?

On the basis of your answer above, determine how the speeds of points A, B, and C compare. Explain.
Demographic data collected

Ascribed characteristics
• Male or female
• Native French speaker
• Parents’ education

Achieved characteristics
• Year \textit{bac} obtained
• Type of \textit{bac} obtained
• First semester (year) grades
• First semester final exam grade (mechanics)
• Hours studied per week
• Hours working for pay per week
## Common conceptual final exam question results

<table>
<thead>
<tr>
<th>Model (N=158)</th>
<th>Coefficients (standard error)</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-0.232 (0.572)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.514 (0.370)</td>
<td>0.100</td>
</tr>
<tr>
<td>Parents’ education</td>
<td>0.027 (0.058)</td>
<td>0.033</td>
</tr>
<tr>
<td>First-semester final exam</td>
<td>0.087** (0.016)</td>
<td>0.403**</td>
</tr>
<tr>
<td>Hours studied per week</td>
<td>0.069* (0.032)</td>
<td>0.158*</td>
</tr>
<tr>
<td>Interactivity</td>
<td>0.966** (0.353)</td>
<td>0.193**</td>
</tr>
</tbody>
</table>

*p<0.05  
**p<0.01
Common conceptual final exam question results

Standardized Coefficients

Male: 0.10
Parents education: 0.05
First-semester exam: 0.40
Hrs studying/week: 0.20
Interactive class: 0.20

*p<0.05
**p<0.01
Survey of students in LP112

Your general opinion of the teaching in LP112 is (N=206):

<table>
<thead>
<tr>
<th></th>
<th>Interactive</th>
<th>Non-interactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very positive</td>
<td>(5)</td>
<td>(8%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6%)</td>
</tr>
<tr>
<td>Rather positive</td>
<td>(4)</td>
<td>(45%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(36%)</td>
</tr>
<tr>
<td>Neutral</td>
<td>(3)</td>
<td>(32%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(27%)</td>
</tr>
<tr>
<td>Rather negative</td>
<td>(2)</td>
<td>(11%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(20%)</td>
</tr>
<tr>
<td>Very negative</td>
<td>(1)</td>
<td>(4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(11%)</td>
</tr>
</tbody>
</table>

AVERAGE SCORE

<table>
<thead>
<tr>
<th></th>
<th>Interactive</th>
<th>Non-interactive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.42</td>
<td>3.06</td>
</tr>
</tbody>
</table>
Survey of students in LP112

To what extent would you say that the way in which teaching took place in LP112 promoted or otherwise impeded your learning of the course material? (N=204)

<table>
<thead>
<tr>
<th></th>
<th>Interactive</th>
<th>Non-interactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Much promoted</td>
<td>(5)</td>
<td>(19%)</td>
</tr>
<tr>
<td>Slightly promoted</td>
<td>(4)</td>
<td>(44%)</td>
</tr>
<tr>
<td>Ineffective</td>
<td>(3)</td>
<td>(15%)</td>
</tr>
<tr>
<td>Slightly impeded</td>
<td>(2)</td>
<td>(20%)</td>
</tr>
<tr>
<td>Much impeded</td>
<td>(1)</td>
<td>(1%)</td>
</tr>
</tbody>
</table>

AVERAGE SCORE

Interactive: 3.59
Non-interactive: 2.95
LP203/LP205/LE207 – second year E&M

LP203/LP205/LE207
N=264

LP203 - CB
N=88

LP203 - PT
N=87

LP205
N=42

LE207
N=47

TD 1

Not interactive

Moderately interactive

Highly interactive
Data collected

- CSEM* pre- and post-instruction
- One common final exam question
- Student demographics
- Student feedback survey (sadly, lost)
- Instructor feedback survey

*CSEM stands for “Conceptual Survey of Electricity and Magnetism”, a research-validated concept inventory on the topics of Electricity and Magnetism
Gauss’s Law

What can be said about the electric field flux through the closed cylindrical surface represented below?

A. It is positive
B. It is negative
C. It is zero
<table>
<thead>
<tr>
<th>Week of</th>
<th>Tutorial</th>
<th>Pretest</th>
<th>Homework Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 3rd</td>
<td>Charge</td>
<td>On: Fri, Sep 30 11:30 am Off: Mon, Oct 3 9:20 am</td>
<td>N/A Problems: N/A</td>
</tr>
<tr>
<td>Nov 7th</td>
<td>A model for circuits part 3: Multiple batteries</td>
<td>On: Fri, Nov 4 11:30 am Off: Mon, Nov 7 9:20 am</td>
<td>Capacitance Problems: All problems</td>
</tr>
<tr>
<td>Nov 14th</td>
<td>Ampere's law</td>
<td>On: Thu, Nov 10 1:30 pm Off: Mon, Nov 14 9:20 am</td>
<td>A model for circuits part 3: Multiple batteries Problems: All problems</td>
</tr>
<tr>
<td>Dec 5th</td>
<td>Faraday's law and applications</td>
<td>On: Thu, Dec 1 6:30 pm Off: Mon, Dec 5 9:20 am</td>
<td>Lenz' law Problems: All problems</td>
</tr>
</tbody>
</table>
B. Two more $+Q$ charges are held in place the same distance $s$ away from the $+q$ charge as shown. Consider the following student dialogue concerning the net force on the $+q$ charge:

Student 1: “The net electric force on the $+q$ charge is now three times as large as before, since there are now three positive charges exerting forces on it.”

Student 2: “I don’t think so. The force from the $+Q$ charge on the left will cancel the force from the $+Q$ charge on the right. The net electric force will be the same as in part A.”

1. Do you agree with either student? Explain.

2. Indicate the direction of the net electric force on the $+q$ charge. Explain.

3. What, if anything, can be said about how the magnitude of the net electric force on the $+q$ charge changes when the two $+Q$ charges are added? Explain.
### CSEM results

<table>
<thead>
<tr>
<th>Interactivity</th>
<th>N</th>
<th>Pre%</th>
<th>Post%</th>
<th>&lt;g&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP205 High</td>
<td>42</td>
<td>30</td>
<td>55</td>
<td>0.29</td>
</tr>
<tr>
<td>LE207/LP203 - 1</td>
<td>124</td>
<td>29</td>
<td>47</td>
<td>0.23</td>
</tr>
<tr>
<td>LP203 - 2 Low</td>
<td>86</td>
<td>28</td>
<td>38</td>
<td>0.10</td>
</tr>
</tbody>
</table>
### Common final exam question results

<table>
<thead>
<tr>
<th>Model (N=131)</th>
<th>Coefficients (standard error)</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-29.345 (19.513)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3.890 (5.517)</td>
<td>0.059</td>
</tr>
<tr>
<td>Parents’ education</td>
<td>2.347** (0.842)</td>
<td>0.221**</td>
</tr>
<tr>
<td>First-year grades</td>
<td>2.880* (1.332)</td>
<td>0.171*</td>
</tr>
<tr>
<td>Hours of studying per week</td>
<td>0.887* (0.430)</td>
<td>0.167*</td>
</tr>
<tr>
<td>Interactivity (^1)</td>
<td>11.820** (3.178)</td>
<td>0.301**</td>
</tr>
</tbody>
</table>

\(^1\)Interactivity is responsible for >1/3 of the \(R^2\) of the model

\* \(p<0.05\)

\** \(p<0.01\)
Common conceptual final exam question results

**Standardized Coefficients**

- Male
- Parents' education**
- First-year grades*
- Hrs studying/week*
- Interactivity**

*p<0.05
**p<0.01
### CSEM results – 1 year later

<table>
<thead>
<tr>
<th></th>
<th>Interactivity</th>
<th>N</th>
<th>Pre%</th>
<th>Post%</th>
<th>&lt;g&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring 2012</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP205</td>
<td>High</td>
<td>42</td>
<td>30</td>
<td>55</td>
<td>0.29</td>
</tr>
<tr>
<td>LE207/LP203 - 1</td>
<td>Medium</td>
<td>124</td>
<td>29</td>
<td>47</td>
<td>0.23</td>
</tr>
<tr>
<td>LP203 - 2</td>
<td>Low</td>
<td>86</td>
<td>28</td>
<td>38</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Spring 2013</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP205</td>
<td>High</td>
<td>32</td>
<td>28</td>
<td>48</td>
<td>0.28</td>
</tr>
<tr>
<td>LE207/LP203 - 1</td>
<td>Medium</td>
<td>89</td>
<td>32</td>
<td>54</td>
<td>0.24</td>
</tr>
<tr>
<td>LP203 - 2</td>
<td>Low*</td>
<td>53</td>
<td>28</td>
<td>41</td>
<td>0.19</td>
</tr>
</tbody>
</table>

*The “Low” interactivity class added a modest amount of IL to their class in 2013*
Instructor feedback

Q: What did you particularly like about the use of interactive learning strategies during your class?

A: Hearing students spontaneously explain their reasoning in front of their fellows during lectures! In a French university, this is a near-miracle. Although tutorials are certainly as beneficial for the students as the use of clickers, it does not make so much of the difference for the instructor.
Instructor feedback

Q: How did your teaching change compared to when you did not use interactive learning in your class?

A: It changed radically, from my point of view for the better. I found teaching much much more satisfactory and enjoyable in Amphi - simply I had a real sense I felt of what is really going on for the students, what they are understanding or not.
A final instructor quote

“At the outset, for various cultural and other reasons, I mentioned that the method would probably not be suitable for foreign students (i.e., not Anglo-Saxon and in particular French).

I was wrong, mea culpa.

Thank you for your efforts concerning the use of alternative forms of learning.”

– British instructor who teaches in French
Conclusions

• Can interactive learning work in France?
  – Yes!
  – Interactive learning strategies led to higher learning gains as measured by
    • research validated concept inventories
    • common final exam questions, both conceptual and traditional problem solving
  – Students generally liked it and found it helped their learning
  – Instructors liked and continue to use it

• IL use in continuing at UPMC, spreading to Université Paul Sabatier (Toulouse)
Questions?