

Chemical engineering education in the digital age

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I am very happy to present in this talk the feedback from my 15 years experience in chemical engineering education in the digital age.

Le Cnam : Conservatoire National des Arts et Métiers

Public education institution dedicated to professional lifelong higher education

- established under the Convention in 1794
- on a proposal by Abbe Henri Grégoire : “to perfect national industry” & “illuminate the ignorance of he who does not know and the poverty of he who has no means of knowing”
- **teaching everywhere for everyone:**
 - ✓ 23 Cnam centers in metropolitan regions
 - ✓ 7 overseas Cnam centers
 - ✓ 4 associated Cnam centers (Ivory Coast, Lebanon, Madagascar, Morocco)
- learners = adults; workers; all different



Marie DEBACQ

Let me first say a few words about « le Cnam »: this French institution is dedicated to professional lifelong higher education; it was established under the French revolution to “illuminate the ignorance of he who does not know and the poverty of he who has no means of knowing”. Or as we say in Latin “*Omnes Docet Ubique*” to provide continuing education open to all, anywhere.

My learners are indeed:

- adults, sometimes with kids;
- workers, often in chemical engineering companies;
- all different (considering their initial training, level and ability).

A short history of chemical engineering distance learning at Cnam

slides with
soundtrack

→ 2004



Marie DEBACQ

To understand how we reached the point where we are today, I would like to relate the history of our chemical engineering distance learning:

We began in 2004: at that time, we produced slides with a soundtrack; a little bit impersonal, perhaps inhuman.

2 main tools

Course studios (recorded classrooms) Plei@d (Learning Management System)

The collage consists of three main parts:

- Top Left:** A photograph of a classroom recording session. A person is writing on a whiteboard. The whiteboard content includes:
 - Header: "Classification de Geldart"
 - Group A: "poudres extensibles" with $\mu_{mB} > \mu_{mF}$ and "catalyseur de craquage".
 - Group B: "poudres à bullage immédiat" with $\mu_{mB} < \mu_{mF}$ and "sables".
 - Group C: "poudres cohésives" with "farines, talc".
 - Group D: "grains soufflables" with "céréales".
 - A graph of $P_p - P_b$ [kg m⁻³] vs dp [μm] with handwritten labels: "A idéale pour fluidisation", "B consistance fluide", "C consistance visqueuse", "D fluide violente".
- Top Right:** A screenshot of the Plei@d LMS interface showing a course page for "Echanges Thermiques" with navigation tabs and a document viewer.
- Bottom Right:** A screenshot of the Plei@d LMS interface showing a "Dispositifs de détection" section with a diagram of a "boîte de commande" containing a "cellule capacitive", "semi-conducteur", and "cristal piézoélectrique".

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Let me focus on 2 main tools which allowed the Cnam to massively develop distance learning in all the disciplinary fields covered by the institution.

The course studios are special classrooms, equipped with a recording device:

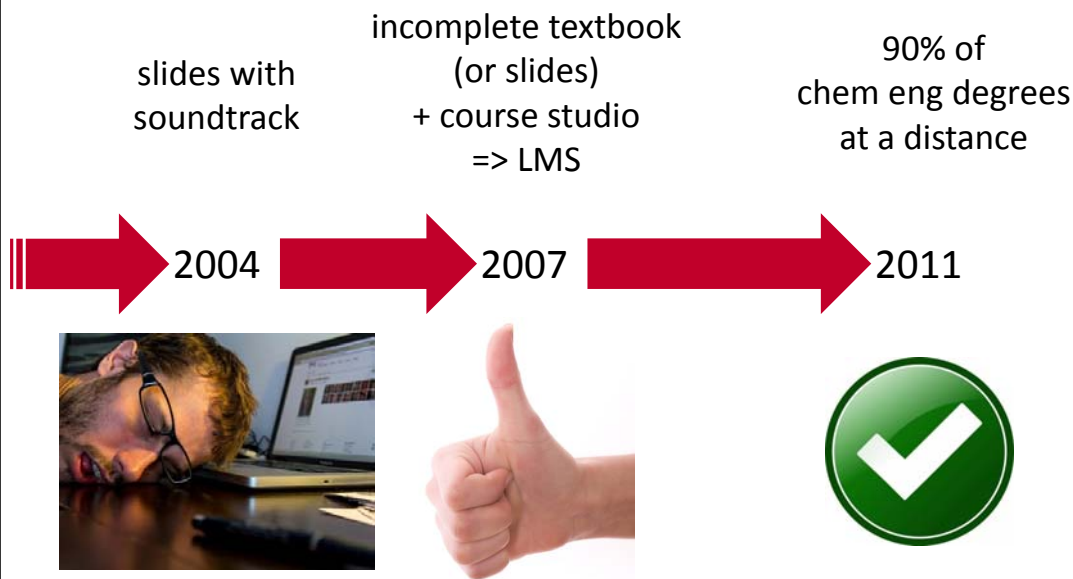
From the control panel, I can choose what I want to record: the interactive board, objects or books, the classroom or myself. And of course, all sounds in the classroom are also recorded. The resulting video is available for all the learners.

Plei@d is a proprietary learning management system. This is what it looked like 12 years ago:

There are several thematic sections for learners to choose from.

And in each section, several documents: PDF, slides with soundtrack, videos, etc.

A short history of chemical engineering distance learning at Cnam



Marie DEBACQ

Up to 2007 my colleagues and I tried several strategies and we converged on using either an incomplete textbook or slides, with fully recorded lectures thanks to the “course studios”. The resources we produced were implemented on Plei@d (the learning platform); on which we also animated discussion forums.

Thanks to this teaching model, we were able to extend distance learning to the whole chemical engineering degree, except the labs. And since 2011 (a bit earlier if you don't consider the optional courses), we have graduates who have obtained up to 90% of the credits towards the engineering degree at a distance.

2007: resources and activities provided on LMS

Classical version:

- copy of slides
- recordings of face-to-face sessions
- (+ online forums)
- (+ recorded group sessions)

My version:

- main resource = "textbook" with gaps
- lectures & tutorials fully recorded during face-to-face sessions in course studios
- online discussion forums
- recorded group sessions
- supplements:
 - ✓ lists of links
 - ✓ demonstration videos
 - ✓ corrected exercises
 - ✓ previous exams

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Here you have the classical organization of a course on Plei@d. I prefer to use "textbooks" with gaps rather than a copy of my slides (which are actually very empty, with few words, pictures and equations basically).

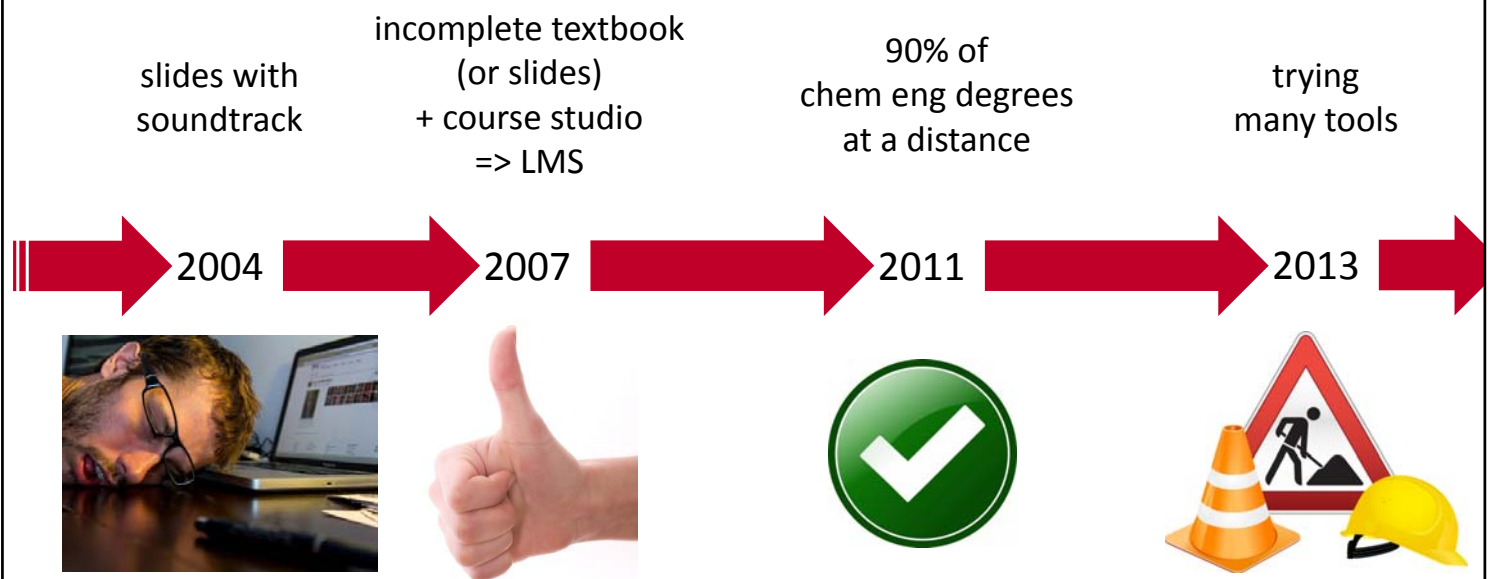
I provide learners with some supplementary resources, to enable them to go deeper into a subject or to train and practice.

One might think that the videos recorded live during the face-to-face sessions are poor quality and much too long, but the learners found it nice to hear others' questions. They find these videos more friendly than the soundtracks that we previously recorded alone in our office.

It is very important to write and draw in real time, and not to have everything written on the slides in advance, even if they are animated.

At this stage, I should point out that I almost never give separate lectures and tutorials: demonstrations, direct applications, practice exercises and problems are included in my lessons. At this time I didn't know the word in a teaching context, but my courses were already scripted...

A short history of chemical engineering distance learning at Cnam



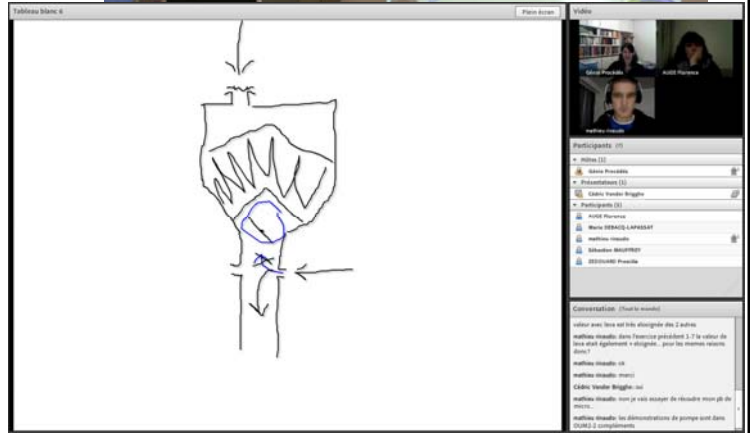
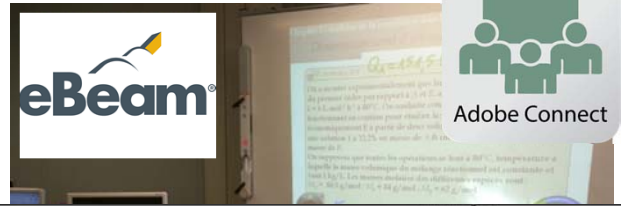
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We and our learners were very happy with that. But around 2013, I began to get bored with this device. So I began to try many different tools, to meet e-learning designers and to read the literature on education science.

2012-2014: many tools experimented

- “nomad” recording solutions
 - ✓ converts any flat white vertical surface into an interactive board
 - ✓ records everything projected & written + the sound

- virtual classroom
 - ✓ learners immediately approved of!



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I needed a "nomad" recording solution for my computer labs. So I tried and adopted the Ebeam device, which allows me to turn any classroom into a “course studio”. You can see the video projector here. The device converts any flat white vertical surface into an interactive board and also records everything that is projected and written as well as the sound in the room.

The webconference system AdobeConnect creates virtual classrooms, that my learners immediately approved of. At this meeting a student drew a diagram to explain his question, and I could also draw to support my explanations. You can see the learners who have a webcam here. For learners who haven't got a headset with a microphone, they can use the chat panel down here.

2012-2014: many tools experimented

- “nomad” recording solutions
- virtual classroom
- publishing chain
 - ✓ pedagogical tags
 - ✓ highly structured content
 - ✓ objectives, intro, concl
 - ✓ additional tools
 - ✓ richmedia

WYSIWYM (what you see is what you mean)

≠

WYSIWYG (what you see is what you get)



SCENARI

Marie DEBACQ



SCENARI is an open-source publishing chain. The principle is WYSIWYM (what you see is what you mean) instead of WYSIWYG (what you see is what you get) like MicrosoftOffice for example: you don't need to worry about the formatting and you focus on educational content. The same content can be automatically published on several supports: textbook in PDF; interactive unit in HTML; or a slideshow.

The self-training modules produced with SCENARI are precisely scripted:

- there are pedagogical tags: definition, basic, supplement, comment, ...
- the content is highly structured: smaller elements are grains and quizzes (MCQ, scheduling, matching, numerical question, ...); you can arrange grains and quizzes to build activities; the activities are dispatched in divisions; and finally the sum of the divisions is the module
 - at each level, you describe the objectives, you have to provide an introduction and a conclusion
 - there are additional tools like references, glossary, nomenclature, etc.
 - and the module is illustrated with richmedia (videos, animations, images, sounds)

2012-2014: many tools experimented



➤ “nomad” recording solutions

➤ virtual classroom

➤ publishing chain

➤ “interactive” quizzes

✓ self-assessment

✓ identify difficulties

➤ etc.

Question 1
Correct
Note de 1,00 sur 1,00

Apparier les équations de lois de vitesse avec la phrase descriptive adéquate.
La réaction considérée est la suivante: $A + B + 2C \rightarrow P + 3R + S$

$r=k C_A C_B$	ordre un par rapport à chacun des réactifs A et B (ordre global 2)	<input checked="" type="checkbox"/>
$r=k C_A C_P$	ordre un par rapport au réactif A et ordre un par rapport au produit P (ordre global 2)	<input checked="" type="checkbox"/>
$r=k C_A^2$	ordre deux par rapport au réactif A	<input checked="" type="checkbox"/>
$r=k C_A$	ordre un par rapport au réactif A	<input checked="" type="checkbox"/>
$r=k C_P$	ordre un par rapport au produit P (réaction autocatalytique)	<input checked="" type="checkbox"/>
$r=k C_B$	ordre un par rapport au réactif B	<input checked="" type="checkbox"/>
$r=k$	ordre zéro	<input checked="" type="checkbox"/>

Parfait, vous êtes fin prêt pour commencer les exercices de dimensionnement de réacteurs.
La réponse correcte est $r=k C_A C_B$ – ordre un par rapport à chacun des réactifs A et B (ordre global 2), $r=k C_A C_P$ – ordre un par rapport au réactif A et ordre un par rapport au produit P (ordre global 2), $r=k C_A^2$ – ordre deux par rapport au réactif A, $r=k C_A$ – ordre un par rapport au réactif A, $r=k C_P$ – ordre un par rapport au produit P (réaction autocatalytique), $r=k C_B$ – ordre un par rapport au réactif B, $r=k$ – ordre zéro

Question 2
Incorrect
Note de 0,00 sur 1,00

Dans un réacteur fermé de volume constant, la pression reste constante.

Sélectionnez une réponse :

Vrai **X**

Faux

NON
C'est faux dans le cas général !
Cela peut devenir à peu près vrai en phase liquide ; en phase gazeuse, cela n'est vrai que si la dilatation stœchiométrique de la réaction est nulle ET que la température ne varie pas.
La réponse correcte est « Faux »

Marie DEBACQ

I really began to produce interactive quizzes when we received our test-platform Moodle.

Moodle allows many types of questions, including the “Calculated question” type, which is really powerful for teaching engineering. When using detailed feedback, series of quizzes can be used as very useful self-assessment. They are also useful for you to identify difficulties or topics that have been misunderstood, and that you can come back to during a virtual classroom or group sessions.

I also tried other tools, that I finally did not retain.

The method

2014:

What about (re)turning to flipped pedagogy?!...



Marie DEBACQ

After considering all these tools, reading some education literature, and talking with e-learning designers, I said en 2014 : What about (re)turning to flipped pedagogy?!... The principle is that activities that are not interactive (the **knowledge transfer** parts) are done at home, and highly interactive or difficult activities are done with the teacher. We promote group activities, research, debates, ...

The idea of the flipped classroom... is not new!



Bertrand SCHWARTZ



Marcel LEBRUN

The main benefits for students:

- understand what they do better
- are much more involved

Marie DEBACQ

Long before the digital century... Bertrand SCHWARTZ, a professor and later the director of the School of Mines in Nancy in the sixties, practiced what was then named the “SCHWARTZ method”: students had to read a textbook at home; then they were assembled for one hour in an amphitheater where they could put their questions to the professor; and then the students had a session doing exercises with a lecturer.

And I taught like this during my first teaching experience: I was one of the lecturers.

Recently I read a lot about flipped classrooms, which have been studied and promoted in particular by the Belgian professor Marcel LEBRUN. The promise of Marcel and others is that with this method, students will understand what they do better and are much more involved.

My various experiments with flipped classrooms

Year	Subject	Nb of learners	Level	Duration [eq. to face-to-face]	Period	Details
2014 & 2016	Hydraulics (applied fluid mechanics, pressure drop and pumps)	50-60	L3	18 h (2 ECTS)	6 to 7 weeks	3 to 4 virtual classrooms 4 recorded face-to-face sessions: - 1 tutorial - 2 work-group sessions - 1 computer lab
2015	Mass transfer	60-70	L3	6 h	3 weeks	1 virtual + 1 work-group sessions
2015	Liquid/liquid extraction	60-70	L3	18 h (2 ECTS)	2 months	3 virtual + 3 work-group sessions
2016	Introduction to distillation	13 apprentices	M1	4 to 5 h	1 month	1 face-to-face session: - "3 min – talks" by pairs - 1 application as a tutorial - work-group (other applications)
2015	Introduction to heterogeneous reactors	15-20	M2	6 h	7 weeks	3 virtual classrooms 3 face-to-face sessions

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I decided to test this strategy first with my hydraulics course.

After this great experiment, I used flipped classrooms in several other courses. This table gives you some information about each of them: As you can see, I tried flipped classrooms with both large and small groups, from L3 to M2 level, always with many meetings: sometimes virtual classrooms, sometimes tutorials, sometimes computer labs AND of course work-group sessions.

The method provides a continuum of resources and activities adapted to all learner situations, from 100% distance learning to 100% classroom delivery, and ensures a smooth transition from one to the other even within the same semester.

The results

First reject, afterwards adopt.

Videos!!!! Quizzesssssssssssssssssss

« Can't ask my questions immediately... search... retain! »
 « Difficult to force myself to work regularly. »

No significant quantitative results.

Change of postures

New skills: **autonomy**; **cooperation**; communication



Marie DEBACQ

At first, learners always found this learning method difficult. But in the end, most of them appreciated it.

They said the videos inserted in the self-training module are essential. And they wanted always more quizzes.

They find it very difficult not to be able to ask their questions immediately; but they also say it is much more formative to search for an answer themselves before asking the question on the forum or during synchronous sessions. Face-to-face learners found it difficult to force themselves to work regularly; this is logical: if they had felt ready for autonomy, they would have enrolled for the distance learning option and not for classes on site. Despite these difficulties, they loved doing the most difficult exercises with me, and not alone at home.

I tried to look at the impact on test scores, but the level of difficulty of the exam was not comparable.

AND academic exams are not the right way to assess this deep knowledge!

This requires a true change of posture: The teacher becomes a guide and is no longer the only one who knows. The learner becomes much more active and open.

Learners acquire new skills: mostly autonomy and cooperation; and to a lesser extent communication (because I don't often ask learners to give talks).

But this also requires more work/time for everyone.

The tools



Marie DEBACQ

If I have enough time, I would like to quickly go through the tools I use.

Producing professional videos

Extracteur simple le cnam

Bilans & titre fictif

bilan matière global sur l'extracteur en régime permanent

$$L_A + V_A = L_1 + V_1$$

bilan en soluté sur l'extracteur en régime permanent

$$x_A \cdot L_A + y_A \cdot V_A = x_1 \cdot L_1 + y_1 \cdot V_1$$

Diagram of the extractor process:

- Input: solution $L_A; x_A$
- Input: solvant (pur) $V_A; y_A (= 0)$
- Process: extracteur
- Output: raffinat $L_1; x_1$
- Output: extrait $V_1; y_1$

Marie DEBACQ - le CnamGP

partment




Marie DEBACQ

Since the Cnam has developed many Moocs, it is equipped with a professional studio, where I can work in the off-peak periods... and record the screencasts I need.

le cnam

Activities

- Assignments
- Choice
- Database
- Feedback / Survey
- Forum
- Glossary
- Quiz



Marie DEBACQ

I use several types of activities provided by Moodle. Some (in black) are true pedagogical activities: Assignments, Database (which can be useful to create a shared library for example), Forum, Glossary, Quiz. The green ones are used to manage the course: Choice to organize the labs for example; Feedback and Survey for the final evaluation of the course.

One activity I use a lot is the webconferencing solution provided by Adobe for virtual classrooms, dedicated to question-and-answer sessions (it is supposed to be able to be used also in Moodle, so could be an additional point here).

I also tried the BigBlueButton service, but I didn't find it as reliable as AdobeConnect.

Some personal recommendations



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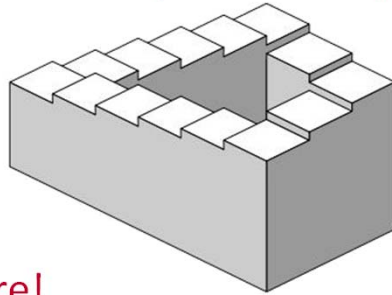
As a conclusion, let me give some personal comments and recommendations.

Enjoy!

Relationship is critical

Section zero = the rules of the experimental game

Step by step



Discuss, discuss and share!

E-learning designers are your best friends!



Marie DEBACQ

Begin with traditional teaching methods (to develop a good group atmosphere and relation with the instructor). And only then, try other methods.

Section zero is very important in order to explain the rules of the game and why you are proposing this new method. Don't hesitate to tell learners that it's an experiment and that you expect feedback from them, comments or even suggestions.

At the beginning you have to –gently! – twist their arm a bit. At the end there will always be a few diehards who don't like the new teaching system, but they're usually a small minority. Introduce these tools and practices STEP BY STEP and update them a bit every year. Talk about teaching methods with your students: The scientific content and the level to be reached at the end of the course are non-negotiable, but the teaching methods can be a joint effort.

Talk things over with other teachers, particularly those in other fields and with classes at different levels, to exchange ideas about methods and tips. Share your content with other teachers in chemical engineering.

Ask e-learning designers for help. Get together with them over a drink because it's often when chatting that the best ideas crop up.

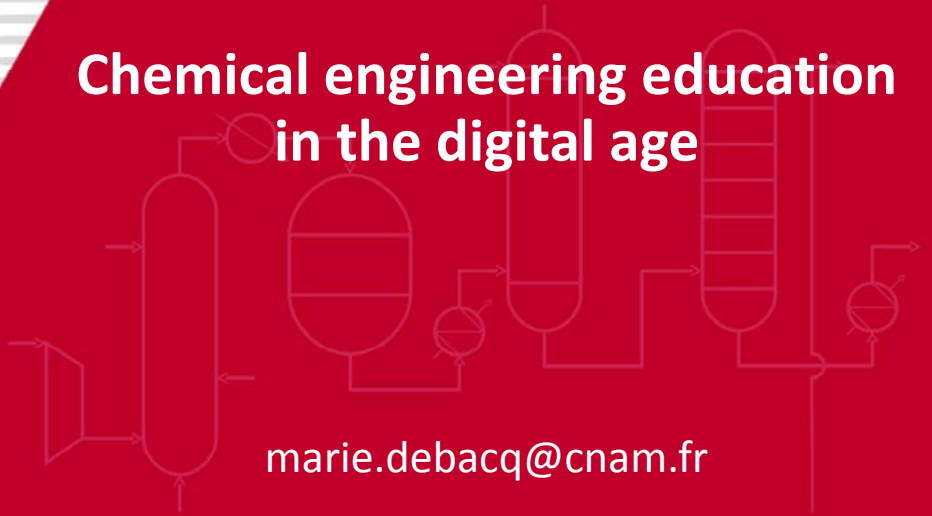
I certainly **don't think** that computers will one day replace teachers – so ENJOY! You'll find out that it's catching...

Thank you for
your attention



le cnam

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Thank you for your attention.