>REVISITING CHEMICAL ENGINEERING EDUCATION

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>INTRODUCTION

- Changing world
  - Depletion of resources, global warning
  - Globalisation of markets, increased competitiveness
  - Importance of digitalization
- Evolution of (Chemical) Engineering professions
  - Expansion of application areas
  - Mobility, flexibility
  - Importance of HSE, Ethics, digitalization,…
- Evolution of learners
  - Y and Z generations
  - Digital native students
- Evolution of teaching methodologies
  - Contributions of neurosciences and cognitive sciences
  - Availability of knowledge
  - New technologies

L'usine du future pour les industries de procédés, white book, SFGP, 2019, www.sfgp.asso.fr

>INTRODUCTION

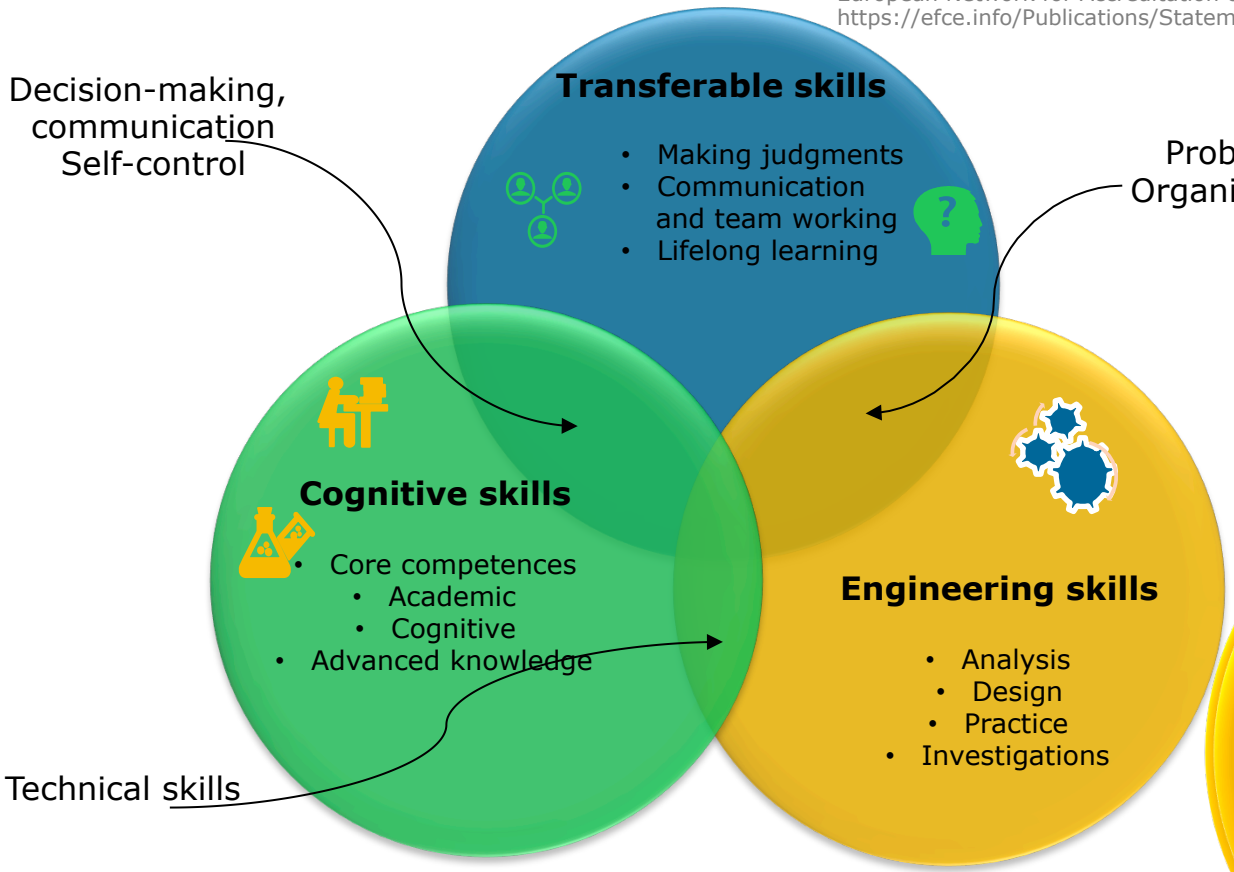
- Should we change something in chemical engineering education ?

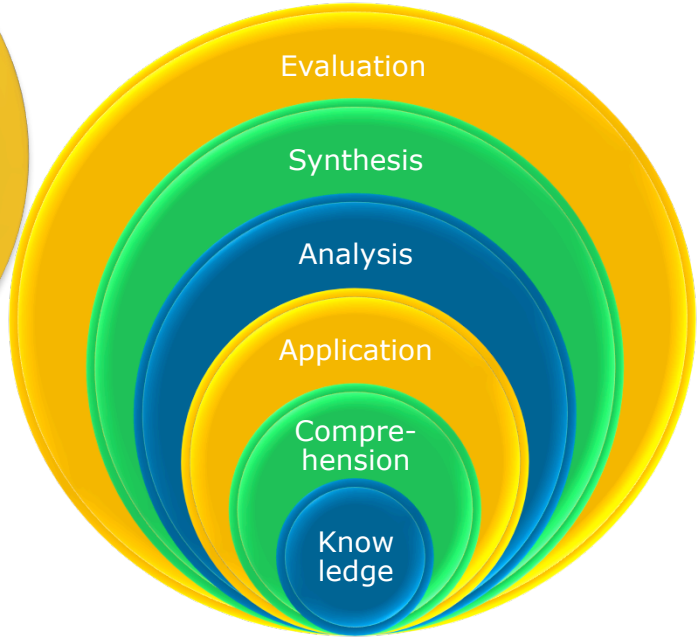
- If yes :
  - Evolution of programmes
  - Evolution of teaching methodologies
  - Conclusion
  - Recommendations

>PROGRAMME STRUCTURE

- Programme outcomes (as defined by ENAEE & EFCE)

European Network for Accreditation of Engineering Education, Standards and Guidelines, 2015
https://efce.info/Publications/Statements+and+White+Papers/Bologna+Recommendations.html





- Described in competences !

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., Krathwohl, D. R., 1956, Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: McKay

>PROGRAMME OUTCOMES

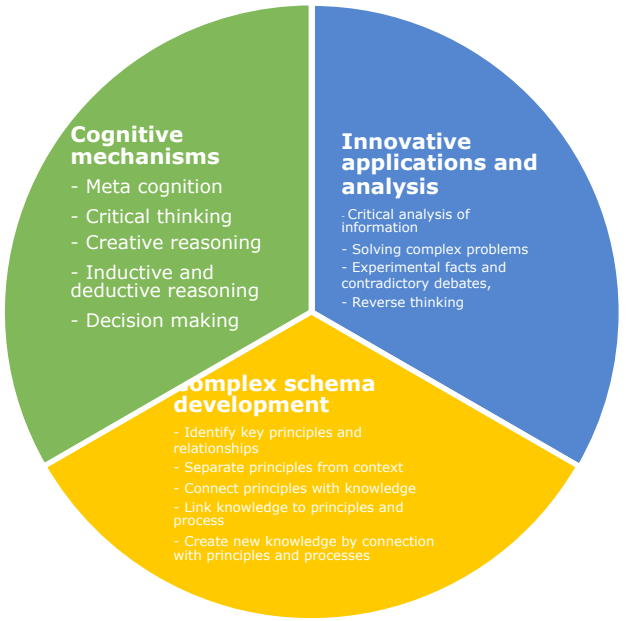
- Importance of basic knowledge & understanding !
  - As recognized by both industrialists & academics (https://research.ncl.ac.uk/iteacheu/, https://chme.nmsu.edu/files/2016/09/2015che_academicindustryalignmentstudy.compressed.pdf)
  - But should include new trends (bio, products, sustainability, dynamics, digital …)
- Engineering skills
  - Should not be reduced (labs, projects, interdisciplinarity…)
  - Internships, co-op studies, participation of industrialists in teaching
- Transferable skills
  - Creativity, problem solving, critical thinking, originality, emotional intelligence, collaboration, interculturalism, …
- All are described for 3 years (180 ECTS) or 5 years (300 ECTS) programmes

>PLANT OF THE FUTURE

- Meet industrial needs and training contents
  - Knowledge and skills in digital technologies
    - Artificial Intelligence, Internet of Things, 3D Printing, Robotics and Automation
    - Modelling, Simulation, Optimization, Intensification, Digital Twin
    - Connected and dynamic factories
    - Predictive maintenance
    - Use & Development of codes
    - Data analysis
    - …
  - Transferable skills

Top skills

1. Solving complex problems
2. Critical thinking
3. Creativity
4. Human management
5. Coordination with others
6. Emotional intelligence
7. Judgement and decision
8. Service orientation
9. Negotiation
10. Cognitive flexibility



Industrie du futur : du système technique 4.0 au système social, Académie des Technologies, 2017

Innovations in Knowledge and Learning: Postsecondary Education Reform to Support Employment and Inclusive Growth, ADB, 2017

>PLANT OF THE FUTURE

- The future chemical engineers will have to deal with
  - Information inflation
    - 5000 publications per day (in 2015)
  - Interdisciplinarity
    - To manage complex problems
  - Internationalization of markets and supplies
    - Multiculturalism
  - Environmental aspects
    - Circular economy
  - Social responsibilities
    - Innovation and risk control
  - Decision making
    - With incomplete or limited information
  - Critical thinking and creativity
    - Innovation, relations with research
  - Ability to anticipate
    - Good knowledge of current societal and technological evolutions

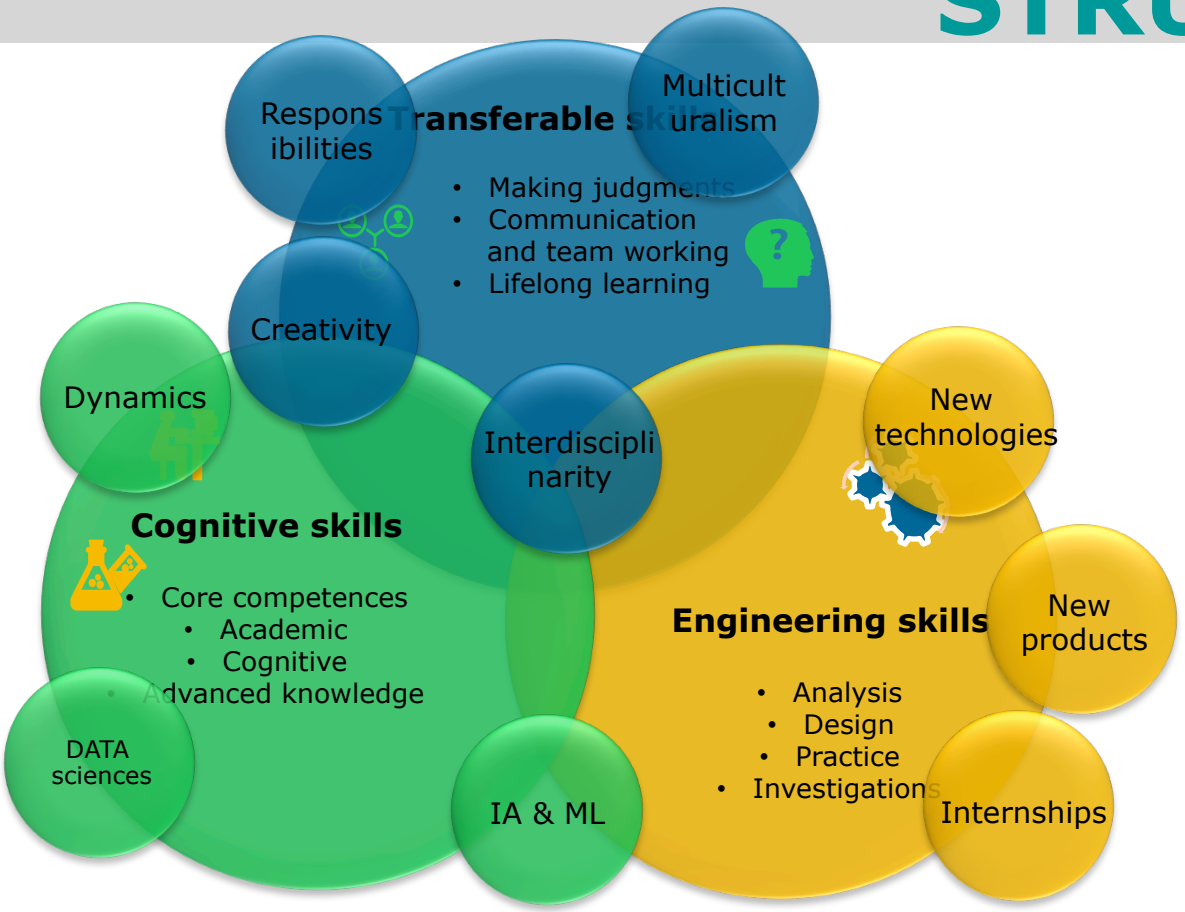
>FUTUR PROGRAMME OUTCOMES

- Basic knowledge & understanding
  - Core topic structure remains adapted to new processes,
  - Balances, Thermodynamics, Transports, Separations, Reactions, Unit Operations
  - Mathematics, Physics, Chemistry, Biology, Informatics & digitalization (data management, digitalization, process control & dynamics, IA, ML)
- Engineering skills
  - Analysis (complex processes, systems & products),
  - Design (of a process or product, also complex),
  - Investigations (application of emerging technologies)
  - Practice (software, equipment, ethics, HSE, economy)
- Transferable skills
  - Can not be developed passively…

Links to research & industry

Active teaching

>FUTUR PROGRAMME STRUCTURE



The (initial) training time seems insufficient to cover all the concepts related to the factory of the future !

- Develop lifelong learning especially as the dynamics of change in industrial production will only become more strained !

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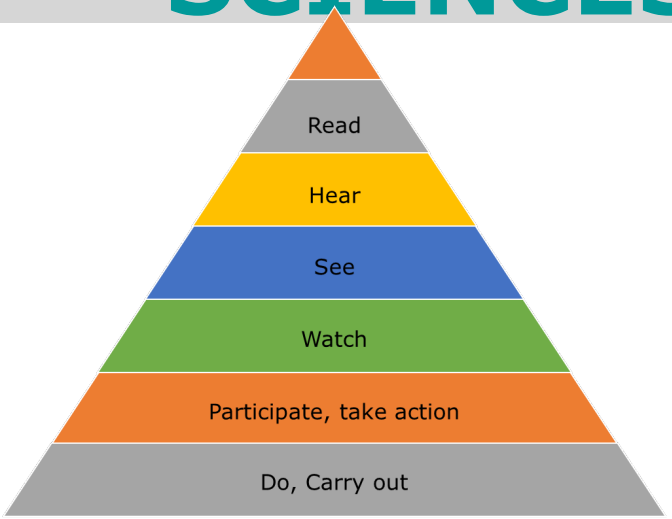
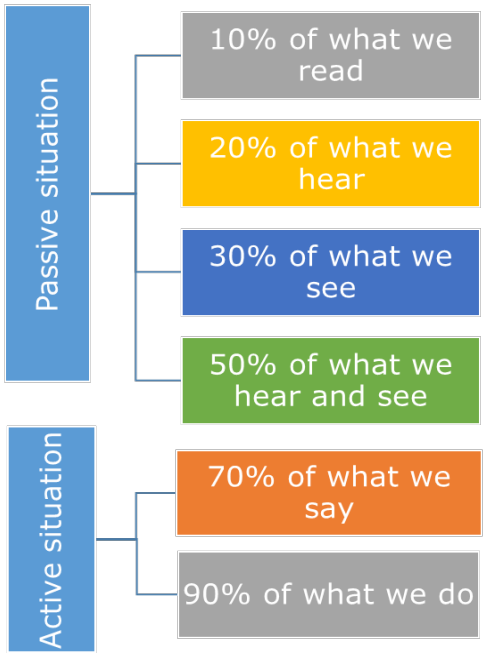
>NEUROSCIENCES & COGNITIVE SCIENCES

- Mutual attention
  - Pay attention to learners' involvement
  - Learners do not always have the right level of information
- Active engagement
  - Promote learning conditions allowing active engagement of learners and cognitive effort
- Feedback
  - Allow time to make mistakes…
- Distribute the learning phases
  - Promote transfer of acquired knowledge



What we remember after 2 weeks

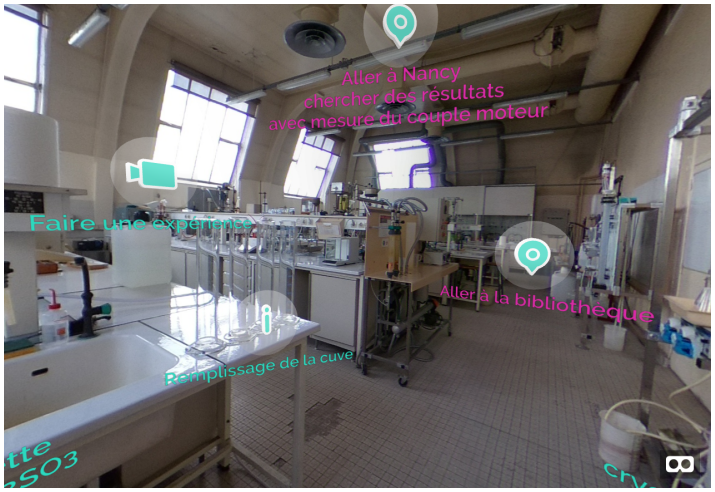


E. Dale, Audivisual methods in teaching, Dryden, New York, 1969

Stanislas Dehaene, Apprendre ! - Les talents du cerveau, Le défi des machines, Odile Jacob, Paris, 2018

>ACTIVE TEACHING

- Methodologies
  - Flipped Classroom
  - Problem Based Learning
  - Project Based Learning
  - Serious Games
  - Blended Learning
  - Online courses…
- Tools
  - Learning analytics
  - Tutorials
  - MOOCs
  - Virtual / augmented reality …



>LEARNING SPACES

- Adapted to active teaching methodologies
- Promoting dynamic and interactive pedagogy
  - Laptop computers, remote screens on the walls, swivel chairs with tablets, interactive digital boards…

  - Video capture for distant learning
  - 3D glasses, virtual reality headset…

>CONCLUSION

- Chemical engineering concepts are necessary for the plant of future
- New emphasis is needed on digitalization & transferable
  - Competencies are to be defined in concertation with employers
  - Some universities have introduced PSE specializations
- Active teaching and tools ensure better involvement of the learners, and are known to improve training, favoring acquisition of knowledge and development of skills
- Time, for acquisition and implementation
  - Propose some specializations
  - Be prepared for lifelong learning

>RECOMMENDATIONS

- Institutions
  - Involve industrialist in steering committees
  - Promote teachers' training
  - Encourage the use of active methodologies, tools & learning spaces
- Industrialists
  - Contribute to the reflexions on teaching contents
  - Be involved in acquisition of engineering and transferable skills
  - Propose internships, co-op trainings
- Teachers
  - Use and develop reflexive teaching
  - Continue to train on innovative technologies and teaching methods
  - Develop & promote lifelong learning activities

>TO BE CONTINUED...

>THANK YOU FOR YOUR (ACTIVE !) ATTENTION !