Education of students and citizens for process development

Arnaud Delebarre[1], Elise El Ahmar[1], Marco Campestrini[1], Willy Morscheidt[2], Marie-Françoise Curto[2]

(1) Mines Paris, PSL Research University, Centre Thermodynamique des Procédés, 35 rue Saint Honoré, 77305 Fontainebleau cedex, France

(2) PSL Research University, Centre d'innovation pédagogique, 60 Rue Mazarine, 75006 Paris, France

Education may be a powerful and efficient tool to promote as well to enhance new material creation as well as new processes to produce them or training to increase society acceptability (Delebarre, 2021). New Information and Communication Technology in Education can help the promotion of the conception, the production and the use of new materials and processes within society. Besides, the use of project work such as Controversy studies in Energy and Environment also contribute to form students to the implementation of new ideas and technologies (Delebarre and Wei, 2019)

It has been a long time since teachers have been looking for new education methods to improve learner motivation and knowledge transfers and thus the acquisition of skills. Furthermore, new materials and new processes often need experimental and theoretical knowledge to characterize the searched properties of materials and then to design the process to produce it. Fortunately, Information and Communication Technology in Education can help in improving the teaching content devoted to attendees such as (i) future or present researchers in charge of the conception of new materials as well as new processes to produce them; (ii) future or present engineers able to design the plants to produce these new materials; (iii) citizens that may enhance the acceptability of innovations and the use of them. Moreover, education to conceive, to design, to produce and to use new products and processes can be helped and supported by massive open online course (MOOC) or small private online classes (SPOC).

This paper aims at showing the motivation and at demonstrating the effectiveness of new methods of learning that may serve the conception of products and processes that produce them. For instance, new methods and tools were used to improve thermodynamics teaching to avoid intrinsic difficulties of this matter and to take advantage of new generation appetence for new technologies. Mines Paris has thus conceived and managed several MOOCs in Energetics ("Problèmes Energétiques Globaux") as well as Thermodynamics ("Conversion Thermodynamique de la Chaleur" and "Thermodynamique Expérimentale"). This paper proposes firstly returns of experience from these MOOC, such as attendance distribution, examination attendance, successful student percentages and quality and effectiveness of learning experience and also their use as self-paced training cursus or SPOC interactive tools (Delebarre et al., 2017, Delebarre et al., 2018).

Then it describes the MOOC "Thermodynamique Expérimentale" devoted to the teaching of experimental thermodynamics for attendants ranging from students (Master or PhD), to personal or customer individuals of process design and maker companies or new fluid or product producer companies. This MOOC may be particularly useful to consider the adaptation of infrastructures conceived for Liquefied Natural Gas to Liquefied Biogas or to characterize new materials/fluids and processes issued from refinery of biomass or to evaluate Carbon Capture Utilization and Storage according to industrial plants. This MOOC includes very specific contents such as the possibility of

virtual practical experimental works by each learner. Some data on examination attendance, successful student percentages and quality and effectiveness of learning experience obtained during three sessions performed on FUN Platform are given.

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