Topic “Eng. Education; Incorporating Societal, Economic & Political Dimensions”

Eco-design, circular economy & social responsibility

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Abstract

Our lifestyle, associated with consumption of large amounts of resources, implies to integrate eco-design in our innovations. In particular, recycling and circular economy have to be facilitated, when designing a product. Life Cycle Analyses (LCA) enable to identify the most impacting stages for environment. They often demonstrate the positive effects of recycling that i) limitates the depletion of natural resources, ii) enables energy savings, iii) lowers dissemination of pollutants, etc. Courses as well as collective projects aim at bringing to light environmental issues of eco-design and circular economy, as well as the resulting questions for engineers & researchers. Social responsibility is also identified as key for circular economy and how to train for social responsibility is discussed. Invited speakers from academia as well as industry provide complementary answers to academic ones.

Key words:
Materials & processes, Eco-design, Circular Economy, Life Cycle Analysis, Social Responsibility.

With the growing technological activity of our civilizations, nature, which was regarded as invulnerable, as having gigantic and inexhaustible resources, today shows signs of disorder and impoverishment that can be directly connected with human activity. The resolution of the questions posed by sustainable development does not only concern sciences and technology but also social responsibility.

In this context, the idea of scientific progress without limits, is perceived as a potential danger related to scientific activity which does not know its consequences with certainty or precision. On the one hand, the conceptualization of sustainable development (in its ethical aspect) slows down the vision of a world in progress for which science, technology, computing power… enables everything to be envisaged. On the other hand, with sustainable development, scientists are asked to find solutions for the practical applications of a development comprising an even greater degree of control (Bourg & Erkman, 2017).

The ideology present in the concept of sustainable development thus appears as still strongly showing faith in science for the resolution of the problems for which technological activity is responsible. While moving towards a scientific application of sustainable development, it appears necessary to think about technological solutions to the problems arising from technology. While posing that the field of resolution of excesses of the technique is even in the heart of the technique, there seems to be no question of minimizing the use of technologies for our development but of reorientating those, to place them within a new conceptual framework allowing their use for sustainable development. Integrating sustainability in higher education is now a worldwide question.

In this context, trans-, inter-, pluri-disciplinarity and complexity inside the sphere of science, technology and also social responsibility seem to be fundamental keys for sustainable development (Massardier, 2014) (Subaï *et al.*, 2006), as the questions posed by sustainable development do not only concern science and technology.

Present developments, whether they concern technology, the environment, the economy or the social sphere, inevitably bring us face to face with the challenges of complexity. The pressure of facts creates the need for this, by the ever-increasing interaction between disciplines and society. Taking complexity into account means introducing a certain way of approaching the real world and defining a special relationship to the object which can only be efficiently elaborated within a pluridisciplinary framework.

The basic questions are always the same and do not only concern finding solutions to problems but also and especially working on the identification and the formulation of the problems themselves. What points of view, what aspects, what frontiers should be taken into consideration in order to treat relevant social problems? And, thereafter, how should we integrate these necessarily (at least partially) conflicting aspects in order to propose satisfying answers?

Once their basic training has been completed, engineers are most often called upon to intervene not merely on isolated technical objects but on socio-technical systems. These systems are often complex. They are also at the intersection of very different approaches (economic, social, technological, political, cultural). Understanding these systems means associating and combining several different viewpoints.

Our students have to acquire and develop an analytical competence and a capacity for a systemic approach and circular economy is a good subject for this. In other words, they need specialist competence and a capacity for pluridisciplinarity. This means that engineer training requires time to be devoted to studying areas of synergy between the specialist fields so that teachers and students are helped in their understanding process.

We are all well aware of the underlying objections to the choice of pluridisciplinarity. But is it really a question of choice? Do we really *have* a choice? Let us rather proceed by analogy with Edgar Morin's definition, according to which a system is both more and less than the sum of its parts.

The complexity of an object, a problem, a situation is the result of a decision. « We are all free to consider an object as simple, but we claim the right to decide on complexity ». By deciding on complexity, we also choose to foreground a new approach to science and consequently, to training.

The question of complexity can be seen as particularly important today, given the need to ensure circular economy, because sustainability brings us face to face with the complexity of the real world.

At INSA-Lyon, the training for circular economy (Massardier & Quitadamo, 2018) is at least available in the departments devoted to industrial engineering, materials science and engineering, associates "hard sciences" and social responsibility.

In perspectives of circular economy, eco-design for anticipating the end-of-life is a key point (Delamarche *et al.*, 2020).

Figure 1 schematises key steps of circular economy. Eco-design, including choice of raw materials, of processes and energy is a main stage for facilitating it. According to us, it requires knowledge as well as skills in disciplines such as chemistry, thermodynamics, physics, mechanics and materials science, associated with social responsibility, that should help choices at each steps of the life cycle. In particular, a relevant choice of the constituents of materials is particularly important as it may prevent recycling. For example, polymer formulations with brominated flame retardants are difficult to recycle, as they are more and more unwanted in new formulations.

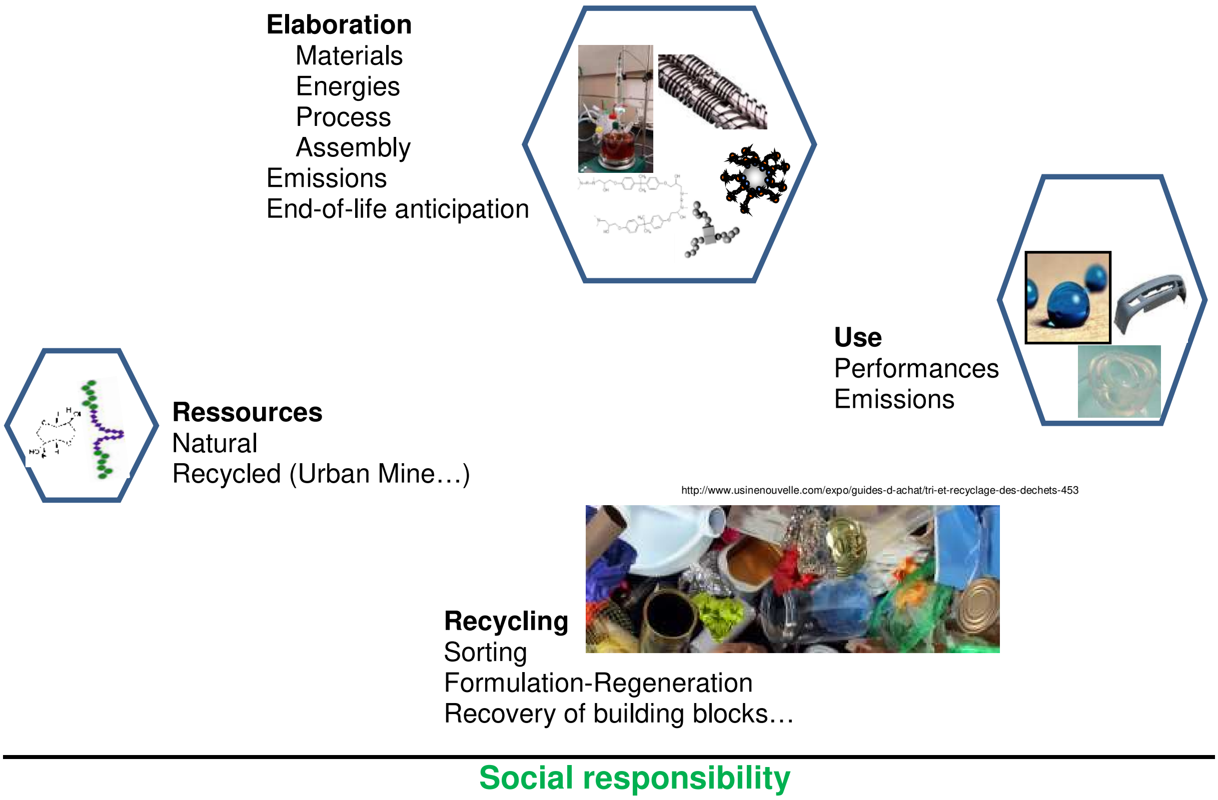

Figure 1: Materials life cycle displaying the need for knowledge as well as skills in disciplines such as chemistry, thermodynamics, physics, mechanics and materials science, associated with social responsibility.

In INSA Lyon, the teaching of social responsibility is often done at Levels Master 2 and often after a significant work experience which takes the form of an internship.
In the industrial engineering department of INSA de Lyon, the training is based on the experience of the students, which, although weak, makes it possible to understand the challenges of companies in a social responsibility approach. It starts with a serious game that provides basic knowledge in sustainable development and presents its challenges for the company. The game continues with a business scenario. First of all, it involves identifying the stakeholders and then making a diagnosis of the business by determining the expectations of external and internal stakeholders. These expectations are then translated into actions. The actions are chosen on the basis of 3 financial criteria and a multi-

year program over 5 years for the company, which constitutes an action plan. Each chosen action must be estimated a priori in terms of impact on 7 factors. The objective of this game, in addition to providing knowledge, is the presentation of possible concrete actions in business. The case study is done at all levels of the company.
This training has been supplemented by the intervention of 3 professionals. The first concerns sustainable purchasing, the second focuses on well-being at work and the last on physical preparation for work. Taking social responsibility into account seems to be an essential component of the educational model, so that engineers are able to argue in favour of its development. Social responsibility may have been opposed to profit. But it can be considered as an investment for a long-term profit. For example, anticipating probable evolutions of regulation, such as REACH, can strengthen a company by enabling it to be a step ahead. Some investment funds, at least, also encourage companies to develop social responsibility and it is important to form engineers able to help in its development. Social responsibility can be considered as a key for circular economy, by eliminating hazardous components to facilitate recycling. For example, recycling of polymer formulations containing hazardous flame retardants or plasticizers such as phthalates, is practically impossible, as it would imply to separate the flame retardants or plasticizers from the polymer matrices. Unfortunately, this separation would be too expensive. Thus, the lack of anticipation when formulating does not permit recycling, with loss of material resources. Moreover, environment impacts are also associated with economical costs
In the meantime, currently, training in social responsibility is taking place as follows: training through serious game, awareness of the responsibility of the engineer and finally training in the implementation of a social responsibility approach. The latter is done in the form of an innovative pedagogy at INSA, it is based on collective intelligence, the idea is to make the student actor and decision maker of his training. It is up to the student to propose the teaching method. This pedagogy is perfectly suited to the teaching of social responsibility. It has its strong points: the involvement of students, the possibility of finding new forms of training, the responsibility of the student in his training. It also has its weaknesses: a lack of investment for some because of the freedom left, the lack of organization, the evaluation which remains difficult. This type of pedagogy is however favored by the students. It will surely be extended in other departments.

To conclude, circular economy requires not only skills in engineering sciences but also social responsibility. As examples, sorting technologies require background in physics for density based methods and spectroscopy for more selective sorting.
Formulation and regeneration require knowledge in chemistry as well as process engineering.
Considering Life Cycle is a way to discuss on global warming, toxicity, ecotoxicity, resources depletion, and also on social aspects. The economical and environment aspects are also discussed, with emphasis on both money savings and benefits on environment often associated with recycling.
Lectures, tutorials as well as projects contribute to our training in circular economy and corporate social responsibility.

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