Teaching of Life Cycle Assessment methodology to sensitize future engineers to sustainable development

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Abstract

The aim of this paper is to present the teaching approach which has been followed concerning the Life Cycle Assessment methodology (LCA). This course was launched three years ago by the Chemical Engineering Department, being aware of the potential of this methodology but also the pressure demand of LCA in industries.

When looking at the Engineer curricula, especially the one of the chemical engineers at University of Liège (ULg), students have a background on environment mainly relative to the technologies to be used to treat air or water pollution. Another approach of environmental issues has been offered to students of the second master in chemical engineering, to increase their knowledge with the learning of the LCA methodology. Before creating this course, these students had only a brief 2 hours lecture, given for more than 10 years as an introduction to LCA to all the students in the second bachelor in Engineering.

LCA teaching activities rely on an expertise developed for more than 15 years as a research domain within the Department. LCA is a methodology used to assess the environmental potential impacts of a product during its overall life cycle, taking into account all stages from the raw materials extraction to the end-of-life.

The course is divided in three parts. First, the environmental context is drawn with the highlighting of the main challenges for the current generation and the future ones. Secondly, the LCA methodology is taught going through ISO standards using mainly applied exercises and several examples of published studies. An introduction to environmental labelling is also given. Students also learn to use a software to model scenarios and obtain results. Teachers give a special attention to show them, using previous examples in the course, the interface function of the tool and the importance of data quality. Results must be explained and justified using their critical thinking. Finally, students are evaluated on a project performed by group of 2 persons. They must criticize, using their acquired knowledge, a scientific paper related to a published LCA study. They must remodel scenarios based on the available data and compare their results with the published ones.

Teachers do not evaluate the modelling results obtained by the groups but the approach they use and how they interpret the results. The main goal of this type of pedagogy is to form future engineers, aware of the future challenges concerning environment and with the sufficient background to manage and to tackle these issues.

1 Introduction

Life Cycle Assessment (International Organization for Standardization (ISO) 2006b; International Organization for Standardization (ISO) 2006a) is a quite new method to assess environmental impacts of a product during its whole life cycle, allowing the avoidance of trade-off between impact categories or steps of production. Even if it is more and more used by policies but also by industrials to assess their

environmental impacts and to help decision, this concept is not always included in the teaching program of future engineers.

Some attempts to include LCA in the educational background of engineers have been performed in several countries, using different pedagogic methods. An educational experience has been conducted in Brazil during 6 years with the UNEP/SETAC Life Cycle Initiative (de Souza Xavier et al. 2014). Another experience has been lead in the USA, where sustainability was introduced in an existing course with a dedicated module to LCA (Paudel and Fraser 2013). LCA has also been implemented as several learning games in a engineering course in Italy (Bevilacqua et al. 2015).

This paper explains the implementation of a new LCA course in the cursus of chemical engineers in the University of Liège in Belgium, the reason of its implementation, its goals and what was expected for and from the students. Some perspectives of improvements are also highlighted.

2 LCA implementation in the University of Liège

2.1 Specific context in Liège

Life Cycle Assessment methodology is a recognized tool to help assessing sustainability and opening minds about environment. In that context, it is a powerful tool that any engineer who will work in industry, academic or public organizations should be aware of.

When focusing on the background of engineers of Liège, and more specifically on chemical or mechanical engineers, some specific knowledge about environment is included in their educational programme. These courses are relative to technologies to be used to treat air or water pollution, so to act downstream. Sustainability in terms of environment is more related to upstream actions as eco-design or processes improvements. As future engineers are also the future designers of our next products, they need a specific knowledge of how to select the best materials and adapted processes being in accordance with the 12 rules of the Green Chemistry (Marques 2014).

Furthermore, one group of the Chemical Engineering research unit has developed an expertise in the LCA field for more than 15 years. Participation of projects from the conception phase of a product until the industrial production has highlighted the need of the integration of environment at each phase of the development of this product.

Aware of this lack in the engineering background of our students, a new course has been launched three years ago for students of the second master in chemical engineering, called Eco-design and LCA. Before creating this course, these students had only a brief 2 hours lecture, given for more than 10 years as an introduction to LCA to all the students in the second bachelor in Engineering.

2.2 LCA course

The course, as given in their last year of study, can be seen as an integrated one, gathering all their previous knowledge about mass and energy balances but also about pollution and environmental treatments.

This course is divided in three parts with a first part based on learning, the second part related to practising and the final one linked to acting and opening their mind.

The first part based on learning highlights the main challenges for the current generation and the future ones in terms of environment. Discussions are opened with students asking them their thoughts about

several current topics as e.g. climate change, water depletion, acidic rains, etc. After this, the concept of environment and current regulations and tools are drawn to explain the context where they live.

The second part is dedicated to the teaching of the specific LCA methodology going through ISO standards using mainly applied exercises and several examples of published studies. A first exercise comparing popcorn and polystyrene chips to fill a box based on their environmental performance is performed as introduction of this methodology (Jolliet et al. 2010). Other examples are used to illustrate some green ideas put in their mind by advertisements or intuition and showing the importance of a complete tool taking into account the whole life cycle of a product to avoid trade-off in terms of steps but also in terms of pollution. To develop their critical thinking, first homework of students is to analyse a published article, to criticize it in terms of environmental relevance and to evaluate if it is in accordance with the ISO standards.

As this second part is dedicated to practice, students also learn to use a software to model scenarios and obtain results. Teachers give a special attention to show them, using previous examples in the course, the interface function of the tool and the importance of data quality. Results must be explained and justified using their critical thinking. Same exercises are proposed to all students, to show how to model and implement scenarios in the software, as well as how to perform energy and matter balances without any software. The most important thing is to analyse results and to understand the limitations of the tool and when its use is not relevant.

The third and final part of this course is a group project focusing on a scientific paper, different from one group to another based on different topics going from insulation and building conception to food going through transport. They receive randomly their topic and must work together to criticize the paper, showing its environmental relevance and its (non)-accordance with the ISO standards using their acquired knowledge. They must also remodel scenarios, using the software and the available data. The goal of this part is to understand the difficulty of the modelling and the importance of choices relative to databases. They have also to compare their results with the published ones and to explain why they obtain this kind of results and what the origin of the differences is. Teachers do not evaluate the modelling results obtained by the groups but the approach they use and how they interpret the results.

3 Conclusions and perspectives

The new course related to Life Cycle Assessment is a first attempt to add, to the educational background of future engineer from Liège, a competence linked to sustainability which can help them to tackle future issues and challenges concerning environment.

This course of three years old has been improved through years, collecting the advices of students and the feeling of teachers concerning the content and the reactions of students. For example, the real work concerning project and the associated modelling have been reduced through years to increase the time dedicated to the interpretation phase. Indeed, this phase is essential to act against greenwashing and increase the awareness of students about the importance of being transparent and relevant to the subject.

The main drawback of this course is the essential focus on environment which is only one of the three pillars of sustainability. Economic and social fields are briefly introduced in this course but due to time and required competences, are not taught in an exhaustive way. An interdisciplinary course could be envisaged for a next future including concepts as circular economy or social justice as it was the case in the USA (Riley 2015).

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