Teaching Students to Integrate Life Cycle Assessment into Product Design through Sustainable Engineering

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Session: Industrial Partnering for Preparing Engineers for the 21st Century Global Economy

Sustainable engineering is the integration of social, environmental, and economic conditions into a product or process. Successful products are developed by integrating Life Cycle Assessment (LCA) directly into the Computer Aided Design (CAD) model. Teaching students to understand, improve, and communicate the environmental impact of their design reflects the current state of the global economy. Engineering parameters such as material selection and the manufacturing process affect carbon footprint, energy consumption, air acidification, and water eutrophication. Learning to compare engineering parameters allows students to be environmentally conscience about their designs. Industry can play a vital role in teaching students to integrate LCA into product design. Through different levels of collaboration and participation, three student activities are explored that incorporate sustainable engineering with industrial partnering.

- Formula Hybrid Competition, Thayer School of Engineering Dartmouth
- Envisioning Sustainable Futures 2 Poster Competition, Worcester Polytechnic Institute
- Vehicle Design Summit, Massachusetts Institute of Technology

Formula Hybrid

The Formula Hybrid [1] competition, founded in 2006, by the Thayer School of Engineering Dartmouth, challenges college and university students to design, build, and race high-performance, plug-in hybrid vehicles. Structured on the Formula SAE program, Formula Hybrid adds fuel efficiency as an extra level of complexity. With technological challenges for students with backgrounds in electrical, mechanical, and computer engineering, Formula Hybrid

encourages interdisciplinary teamwork and innovation. In 2010, to further encourage innovation for efficiency, the teams will be required to complete the 22-km (13.7-mi) endurance event on a reduced amount of fuel. The 2010 fuel allocation has been reduced to 2.3 liters (0.61 gal) from 4.7 liters (1.24 gal) in 2009. This equates to 9.57 km/liter (22.5 miles/gallon)—an unheard of efficiency in a race car.

SolidWorks worked with Formula Hybrid to incorporate an emphasis on sustainability in design where student teams will be scored on their understanding of the consequences of their design decisions on the environment.

LCA is a method to quantitatively assess the environmental impact of a product from the procurement of the raw materials, through the production, distribution, use, disposal and recycling of that product, these being the stages which constitute the product's lifecycle. The LCA process evaluates the effects that a product has on the environment over the entire period of its life thereby increasing resource-use efficiency and decreasing liabilities. It can be used to study the environmental impact of either a product or the function the product is designed to perform and the transportation between stages. LCA is commonly referred to as a "cradle-to-grave" analysis.

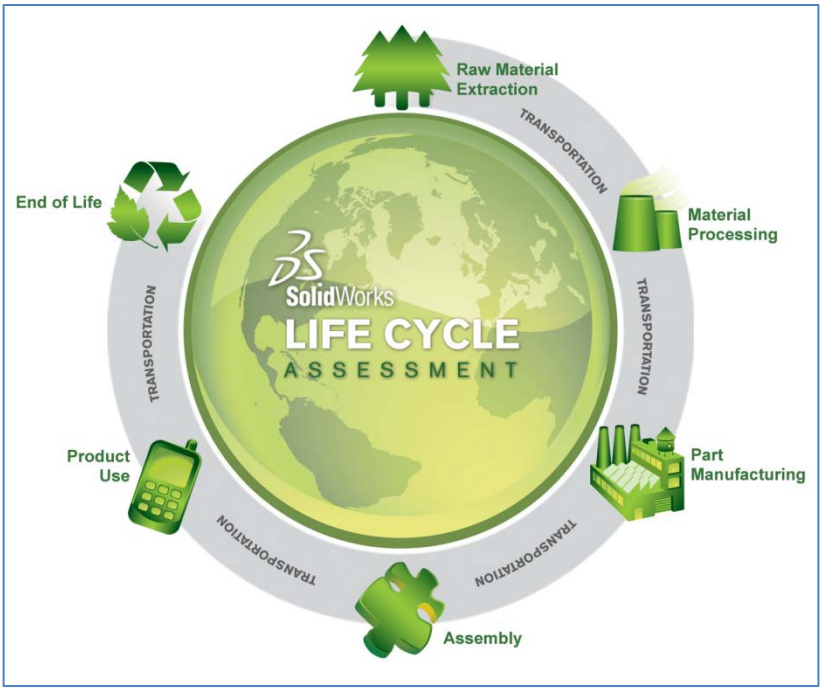

Figure 1 Life Cycle Assessment (LCA) Model

LCA's key elements are: (1) identify and quantify the environmental loads involved; e.g. the energy and raw materials consumed, the emissions and wastes generated; (2) evaluate the potential environmental impacts of these loads; and (3) assess the options available for reducing these environmental impacts. The LCA framework is based on ISO 14044[2].

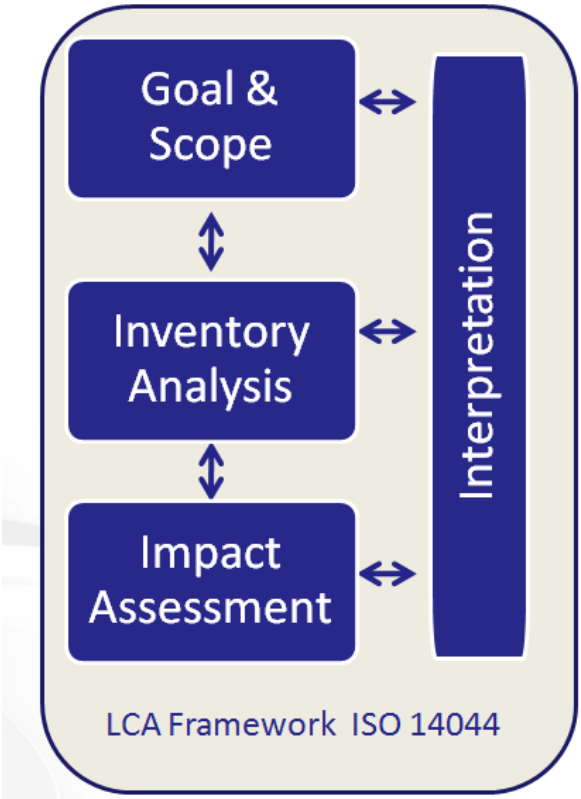

Figure 2 LCA Key Elements ISO 14044

Students provide a LCA on a part by selecting Material, Manufacturing Process, Manufacturing Region, Transportation and Use and set a base line. By selecting similar materials based on material properties such as density, tensile strength, specific heat, thermal expansion, elastic modulus, inputs are modified to see the effects on Carbon Footprint, Energy Consumed, Air Acidification and Water Eutrophication.

Reports are produced comparing different inputs to the baseline. In addition, students compare environmental impacts into human scale parameters such as carbon footprint converted into miles driven by a car or contamination of a household's worth of water in a year.

Note: At the time of this writing, student results had not been completed, however, results will be presented at the final ASEE Northeast Conference.

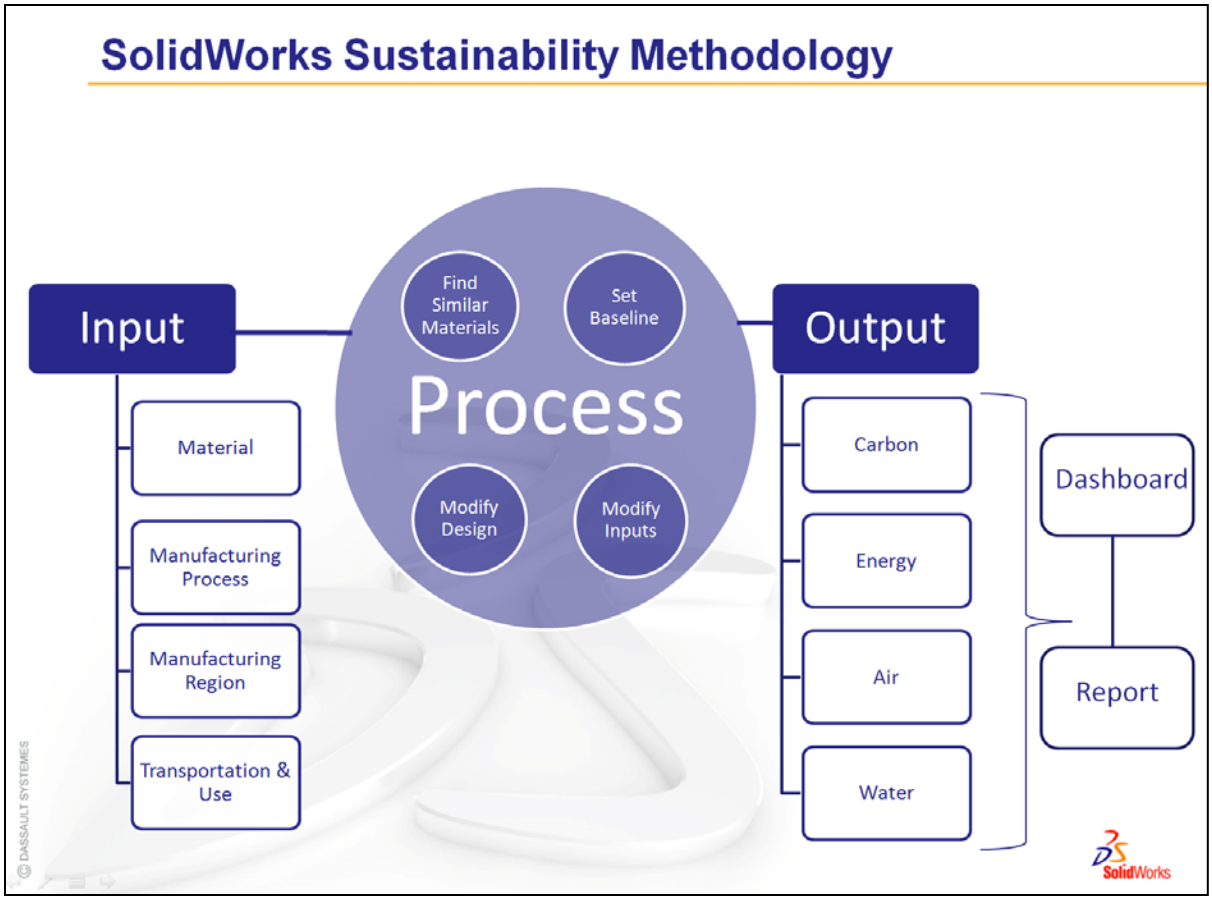

Figure 3 Sustainability Methodology

WPI Sustainability Poster Competition

As part of WPI's 2010 Earth Day Celebration, the WPI Task Force on Sustainability[3] and the Environmental Studies Program will be sponsoring a sustainability-themed poster contest. By providing judges and SolidWorks Sustainability applications, DS SolidWorks Corp. will also participate in the competition that will take place on April 21, 2010. The competition is divided into two categories: (1) Technological responses to a problem associated with greening or sustainability and (2) Interdisciplinary projects that focus on socio-technical dimensions of social

or environmental sustainability. According to US News and World Report[4] , sustainability is introduced to WPI freshman in friendly dorm competitions and recycling efforts.

MIT Vehicle Design Summit

To address the growing need for collaboration skills, an international consortium of colleges and universities spearheaded a program three years ago with DS SolidWorks Corp. and other industries that engages students around the world to collaborate on a project aimed at solving the global problem of greenhouse gases and excessive harmful emissions. The Vehicle Design Summit (VDS) program [5] encourages students to work in teams to design, build and test alternative transportation technologies and prototype commuter vehicles. Compelling students to think about developing sustainable vehicles that reduce emissions and landfill disposal drove the need for collaboration to discover approaches that would meet all of the project's goals. Working in teams on sustainable design projects prods students to ask questions they normally wouldn't, such as: What do the raw materials cost? How reliable is the quality? Is there a material that costs the same but is easier to recycle? The answers have come from pooling knowledge between teams at 12 member institutions located across the globe.

Figure 4 Pulse Car MIT Vehicle Design Summit

VDS seeks to establish a permanent consortium of star-performing teams whose example might be followed by "prospective" teams. VDS organizers expect up to 35 teams from around the world to participate. Some of the key participants include:

Participants in Vehicle Design Summit	
UC Davis (USA)	MIT (USA)
GroepT Technical University (Belgium)	Politecnico di Milano (Italy)
RWTH Aachen (Germany)	Makerere University (Africa)
Delhi College of Engineering (India)	Tsinghua University (China)
Montreal Polytechnique (Canada)	Imperial College (London)
Princeton University (USA)	Smith College (USA)

Design for the public good

Just as the open source movement has delivered significant benefits to the computing industry, the VDS will make its discoveries open to the public domain. By sharing the latest innovations in sustainable transportation, VDS organizers hope to spur widespread funding, design, development and adoption of eco-friendly vehicles. Doing so will not only foster continued innovation from academia and industry alike, but it will also fuel collaborative development of solutions to other global challenges. Moreover, it will further ignite the curiosity and commitment of an increasing pool of qualified engineers around the world.

Industry Partnerships in Sustainability to Continue

Industry must play a vital role in teaching students to integrate LCA into product design. Through contests, posters, presentations, industry speakers, and classroom curriculum, fundamentals of sustainable engineering will bring about the skill sets students will need to develop successful products that are developed by integrating Life Cycle Assessment (LCA) directly into the Computer Aided Design (CAD) model. To understand, improve, and

communicate the environmental impact of their design, allows students to be conscience about their future.

References

1. Formula Hybrid: http://www.formula-hybrid.org/
2. Environmental management -- Life cycle assessment -- Requirements and guidelines ISO 14044 www.iso.org
3. Sustainability Task Force: http://www.wpi.edu/about/Sustainability/
4. *5 Unique Ways to Go Green if You're Living in a Dorm*, Miners, Zach, US News and World Report, January 28, 2010
5. MIT Vehicle Design Summit: http://www.vehicledesignsummit.org

Author Biography

Marie Planchard brings more than 25 years of professional and academic experience in the CAD industry to her role as SolidWorks Corporation's director of world education markets. She is responsible for global development of curricula and content for SolidWorks educational products across all levels of academia. Planchard has co-authored 20 CAD textbooks, holds CSWA and CSWP certification, MSME from Worcester Polytechnic Institute, and BSME from Rutgers University. She has been a member of ASEE for 15 years and an Oppenheimer Award winner.