Adding Context to First-Year Engineering Design Experience through Sustainability

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The first year of the engineering curriculum at University of Detroit Mercy UDM includes a course titled Engineering Graphics and Design that is required of all engineering majors. This type of course is very common and achieves, among others, the following objectives: it gives the student an exposure level experience with the various engineering disciplines; it provides the student with the training to communicate using engineering drawings; and, it leads the student through the design process.

The value of teaching design to freshmen students is well documented[1,2] and is understood to help with the all-important retention[3] into the second year and beyond. More importantly, the National Academy of Engineering released two reports imploring the engineering education community to provide context to engineering design projects[4,5] and to do so very early in the curriculum. The all-important context to the engineering projects has manifested itself in a number of ways. The oldest and, perhaps, the most prevalent practice is the industrially sponsored project which brings real-world, actual engineering cache to the design experience.[6] In the mid 1990's, the focus in the engineering education literature seem to have shifted towards "bottom-of-the-pyramid" design projects[7-9] which provide "more emphasis on the social, environmental, business, and political context of engineering"[10] as described by the Committee on Engineering Education of the National Academy of Engineering and strongly encouraged and funded by organizations such as the National Collegiate Inventors and Innovators Alliance NCIIA (www.NCIIA.org). More recently, around the mid 2000's, a newfound focus emerged on Sustainability and Green Engineering.[11] This was not as much a change in focus as a realignment as sustainability is a prerequisite to the long terms success of anything and thus will benefit whatever endeavors one undertakes. One need only look at a brownfield that used to be an industrial site in a developed country to realize that thinking about the future is critical at the planning and design stage. The work presented here is in response to the need to add sustainability into the engineering curriculum and draws on a number of examples that can be found in the literature.[12-14]

After deciding to create a module on sustainability to be introduced into the freshman design class, the question turned to the manner and form that such a module will take. The module had to cover all six of Bloom's level of cognitive development[15,16] (knowledge, comprehension, application, analysis, synthesis and evaluation) and to do so in a short time of three contact hours. The compressed timeline and diversity of requirements associated with introducing a demanding subject such as sustainability necessitated the use of a software platform. The software chosen for this module is Sustainable Minds[17] (http://www.sustainableminds.com/).

The module employs the terminology of Life Cycle Assessment LCA used by the Sustainable Minds software and in particular, the concepts of process flows vs. environmental impact categories. The process flows consider the energy, water and materials use and environmental releases; such as, air emissions, solid waste disposal, and wastewater discharge of the product are considered and measured. The environmental impact categories consist of the categories of human health and ecological effect, namely ozone depletion, smog, acidification, global warming, ecotoxicity, among others.

The learning outcomes associated with this module, as related to Bloom's levels of cognitive development are given in the following table.

	After partaking in this module, students should be able to:
Knowledge	Define the terminology associated with process flows and environmental impact categories.
Comprehension	Describe the effects of LCA's impact categories and process flows as relate to the health and future of the human race.
Application	Calculate the environmental performance of a particular concept design using the Sustainable Minds software.
Analysis	Compare and contrast the environmental performances of various concept designs.
Synthesis	Devise an optimal concept design in terms of environmental performance.
Evaluation	Justify the choices made.

The authors will showcase the module and relate the work to several concepts of a disposable drinking cup for hot liquids.

[1] Dym, CL. 1994. "Teaching Design to Freshmen: Style and Content." *Journal of Engineering Education* 83 (4): 303–310. http://www2.hmc.edu/~dym/4-JEE1994E4.pdf.

[2] Sheppard, Sheri, and Rollie Jenison. 1997. "Examples of Freshman Design Education." *International Journal of Engineering Education* 13 (4): 248–261.

[3] Knight, Daniel W, Lawrence E Carlson, and Jacquelyn F Sullivan. 2007. "Improving Engineering Student Retention Through Hands-On , Team Based , First-Year Design Projects." In *31st International Conference on Research in Engineering Education*, 1–13. Honolulu, HI.

[4] National Academy of Engineering. 2004. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: The National Academies Press.

[5] National Academy of Engineering. 2005. *Educating the Engineer of 2020*. Washington, DC: The National Academies Press.

[6] Lamancusa, John, Allen Soyster, and Robert George. 1997. "Industry-Based Projects in Academia - What Works and What Doesn ' t." In *1997 ASEE Annual Conference*.

[7] Turley, Richard T., Tanisha White-Phan. 2010. "Project Management Techniques for Student." In *2010 National Collegiate Inventors and Innovators Alliance*, 1–11. SAN FRANCISCO, MARCH 25-27, 2010.

[8] Coyle, E. J., Jamieson, L. H., & Oakes, W. C. (2005). EPICS : Engineering Projects in Community Service. *International Journal of Engineering Education*, *21*(1), 000–000.

[9] Newcomer, Jeffrey L. 1997. "A Broadened Perspective : Teaching Engineering Design in a Social Context Capstone Design and Education." In *Frontiers in Education Conference, 1997. 27th Annual Conference. Teaching and Learning in an Era of Change.* 981–986.
[10] National Academy of Engineering. 2005. *Educating the Engineer of 2020*. Washington, DC: The National Academies Press, page 105.
[11] Anastas, P.T., and Zimmerman, J.B. 2003. "Design through the Twelve Principles of Green Engineering." *Env. Sci. and Tech* 37 (5): 94A–101A.
[12] Allen, David, Braden Allenby, Michael Bridges, John Crittenden, Cliff Davidson, Scott Matthews, Cynthia Murphy, David Pijawka, and Cynthia Nolt-helm. 2008. *Benchmarking Sustainability Engineering Education: Final Report: EPA Grant X3-83235101-0*.
[13] Basu, Anuradha, Asbjorn Osland, and Michael Solt. 2008. "A New Course on Sustainability Entrepreneurship." In *2008 National Collegiate Inventors and Innovators Alliance*, 71–78.
[14] Desha, Cheryl J K, Karlson Charlie Hargroves, Michael H Smith, and Peter Stasinopoulos. 2007. "The Importance of Sustainability in Engineering Education : A Toolkit of Information and Teaching Material." In *Engineering Training & Learning Conference*, 1–14. Australia, 12-13 September 2007.
[15] Bloom, B.S. and Krathwohl, D.R. 1974. *Taxonomy of Educational Objectives: The Classification of Educational Goals*. D. McKay. http://books.google.com/books?id=emfuAAAAMAAJ.
[16] Anderson, L.W. and Krathwohl, D.R. and Bloom, B.S. 2001. *A Taxonomy for Learning, Teaching, and Assessing: a Revision of Bloom's Taxonomy of Educational Objectives*. Longman. http://books.google.com/books?id=JPkXAQAAMAAJ.
[17] Design greener products right, from the start | Sustainable Minds. (2011). *Design greener products right, from the start | Sustainable Minds*. Retrieved June 30, 2012, from http://www.sustainableminds.com