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Abstract

The paper addresses an issue of setting a new standard of engineering education by development and support of competitive curriculum for specialized and innovative design education, which will strengthen the capability of students at Mechanical Engineering with the skills and inception of industrial design. Three courses appropriate to the needs and developmental levels have been newly developed and briefly discussed with each case example of the class projects.

Keywords: design education, engineering education, mechanical engineering

1. Introduction

Nowadays global technology leaders in industrial field emphasize the importance of seamless Product Lifecycle Management (PLM), an integrated, parametric-based approach to all aspects of a product's life–from its design inception, through its manufacture, marketing, distribution and maintenance, and finally into recycling, disposal and reuse/sustainability [Stark, 2006]. In 1949, Duetsch reported that mutual cooperation between students, rather than the competition invoking negative effects on the relation, could bring a positive independency between them so that they might be likely to solve the given problems easily and effectively[Duetsch, 1949] and similar research results can be found elsewhere[Parrenas 1993, Ediger 1996, Johnson & Johnson 1999, Taur & Harackiewicz 2004]. It has been also insisted that the maximum effect of engineering education can be acquired by structuring education system rather than the education itself and, accordingly, students under the well organized team collaboration are likely to become more eligible to adjust themselves to the competitions with other teams when performing the class project[Attle & Baker 2007]. The students of MSID at HIU have long been educated via a cooperative engineering design specific curriculum appropriate to the needs. Three major courses of MSID targeting cooperative engineering design, Creative Engineering Design (freshman), Design Process (Senior), and Creative Product Development (Junior), are all based on 'hands on experience' that all of the students involved in the course communicate with each other through the deliverables made during the course projects, in which, after all, will help students enlarge their creativity, cooperation, and communication with other team members in the class.

In 2008, a multidisciplinary global automotive development project sponsored by PACE(Partners for the Advancement of Collaborative Engineering Education) has firstly begun in order to design, model, analyze, and integrate multiple working components of a marketable automobile product to be further fabricated as a car prototype. One of the successful it has realized is an educational environment for multidisciplinary automotive development project made with other global institutions worldwide. The key concept of this project mainly focuses on better preparing students for their professional career in an international engineering environment and timely adjustment on the job after graduation. It also accelerates students design and manufacturing skills, while giving them the experience of global communication for large scale collaboration. The students and faculty from these distinguished PACE Institutions experienced the importance of bridging regional and international engineering standards, languages, and geographical and social boundaries [PACE 2007]. This objective demands the intimate partnership between industrial design and engineering from different disciplines worldwide as well.

Design education for engineering has been also a keen issue to establish a robust education curriculum for undergraduate engineering students [Harrison 2001], and the economic growth of a country, strongly supported by heavy industries including automaker, shipbuilding, and plant industry, generally requires a paradigm of sustainable and persistent provision of future-oriented human resources of engineering and, as the indispensable condition, the educations for engineering students, especially for the mechanical ones, are now asked to be further reinforced by design specific curriculum. The universities, as they conduct the educations for future employees of the industrial company, now have to keep up with the needs in order to facilitate its competitiveness in the market.

In fact, the theme of 'capstone design' has long been traced as the best curriculum of design education for the engineering students in Korea and supported by most universities through the "Specialty Curriculum Development Program", usually funded by the Ministry of Education, for nurturing qualified engineering students. Since designers and engineers usually have not closely worked together, however, the design-engineering link is likely to be the most fragile and their weak collaboration still poses a significant problem even in the academic setting as well as work environments in industry. Since 2008, Mechanical System & Design Engineering (MSDE) department at Hong Ik University(HIU) has begun a new curriculum project. The prime objective of an educational environment for the new approach is to strengthen the capability of students at Mechanical Engineering with the skills and inception of industrial design. The faculty members in the engineering departments are now attempting to develop and establish a competitive curriculum for specialized and innovative design education with the industrial design skills and design inception for setting a new standard of engineering education. Three courses appropriate to the needs and developmental levels have been newly developed as in the followings:

Form and Aesthetics for Engineering Design(FEED)
Design Visualization & Simulation Methods (DVSM)
Green Product Design & Development (GPDD)

All these courses are based on personal tool exercises for design software and hardware and team-project group activities of the students with other team members. In this paper, syllabi of those courses are briefly discussed with each case example of the class projects [Dresselhaus 2011].

2. Design Education Courses for Mechanical Eng.

These courses are primarily for undergraduate students in Mechanical Engineering, but are also valuable for students in business, design, engineering, science and technology. These are taught in a modular framework with a hands-on topic each week of the term as shown in table 1. The syllabi of the courses are now briefly explained and discussed with each case of class project.

Table 1. A course framework for the new curriculum [Dresselhaus 2011]

Course Status	Product Design Engineering Foundation Course
Course Term	Spring or Fall semester annually
Course Credits	3
Class Hours	3(2+1) per week
Course Type	Design Studio

2.1 Form & Esthetics for Engineering Design (FEED)

This is a foundational overview and discovery course covering the basics of design form and esthetics development. Every designed physical entity or product inherently has some form. Whether that form is attractive and functional to humans depends upon the quality of the design and the skill of the designer. In a world where human-centered design solutions are essential, the responsible product design engineer is obligated to appropriately address design esthetics and form as a universal human need. Though design form can affect many areas of human interaction, this course will emphasize visual and ergonomic esthetic development. The course material is focused around product design and engineering and will emphasize logical or objective esthetics. The students will learn the basic principles, tools and methods of design form development within a comprehensive approach to human-centered product design and engineering. The format will be based on Instructor-delivered lectures and coaching of best-practice fundamentals that can be applied in any situation where human-centered esthetic form solutions are required. The Instructor will present topical lectures of principles, tools and processes with examples, visuals and case studies and launch student projects. The course is based upon the philosophy that design is a universal, comprehensive human activity of learnable principles, processes and skills that can be applied to resolving a variety of human needs in a broad array of situations. Two- and three-dimensional sketching and visualization techniques will be taught and utilized throughout the course as the primary medium of executing student exercises and projects.

The brief course schedule is listed as in the followings:
Session 01: Introduction to Course and Syllabus
Session 02: Design Form, Esthetics and Ergonomics
Session 03: 2D and 3D Visualization and Sketching of Design Form (ongoing)
Session 04: Objective and Subjective Esthetics
Session 05: Design Semantics and Language
Session 06: Esthetic Information and Expression
Session 07: Geometric and Organic Form
Session 08: Contrast and Novelty
Session 09: Alignment and Orientation
Session 10: Proportion and Symmetry
Session 11: Two- and Three-Dimensional Curves and Surfaces
Session 12: Color and Texture
Session 13: Integrated Form and Esthetic Applications
Session 14: Objectified: Movie Analysis and Discussion
Session 15: Final Project Presentations and Displays

Fig. 1 shows an example, a coffee maker, of student project results made in the course of FEED.

Figure 1 A case example of FEED product design (coffee maker [Dresselhaus 2011])

2.2 Design Visualization & Simulation Methods (DVSM)

This is a knowing-doing studio-based design fundamentals course and is foundational to further work in product design and engineering. The students will both learn and practice the basic principles, tools, skills, materials and methods of 2D and 3D analog and digital design visualization and simulation (vizsim) as applied within a comprehensive approach to design process. This course will be based on instructor-delivered lectures and coaching of best-practice fundamentals that can be applied in any situation where creative design development, process and solutions are required. The course philosophy is based upon the idea that the fundamental creative tool of design is the visualization and simulation of ideas, concepts and solutions throughout the design process. It is the intent of this course to prepare the students to have at their personal disposal four levels of design visualization and simulation tools and skills applicable to their creative design development. These four levels are: a) freehand/analog/physical 2D sketching and visualization, b) analog/physical 3D sketching and mockup making, c) 2D and 3D digital and virtual sketching and visualization, and d) knowledge and application of sophisticated digital and virtual modeling, prototyping, animation and presentation tools and methods.

The brief course schedule is listed as in the followings:
Session 01:Introduction, Syllabus Review, and design VizSim and Course Overview
Session 02:Analog (Manual/Physical) and Digital VizSim and Their Tools and Materials
Session 03:2D and 3D VizSim and Their Various Applications
Session 04:Perspective Drawing Principles and Construction
Session 05:Freehand vs. Instrument/Guides Construction and Sketching
Session 06:Diagramming and Schematics Methods Using Images, Photocopies, Underlays, Keypoints and Photos as Sketching Basis
Session 07:Orthographic Drawing for VizSim, Design and Layout
Session 08:Adobe Illustrator/Photoshop and Autodesk Sketchbook for Digital VizSim
Session 09:Physical Mockup and Model Construction Methods and Materials
Session 10:CAID, CAE and MCAD Tools, Software and Methods for VizSim Using VizSim for Design Narratives, Stories and Scenarios
Session 11:Keynote and PowerPoint for Presentation Visualization
Session 12:Beyond Just Visualization to Sensorization
Session 13:Analog, Digital and Rapid Prototyping
Session 14:Engineering Analysis and Simulation
Session 15:VizSim Management and Process Integration

Fig. 2 shows an example, a microscope, of student project results made in the course of DVSM.

Figure 2 A case example of DVSM product design (microscope, [Dresselhaus 2011])

2.3 Green Product Design & Development (GPDD)

This is a basic foundational product design and engineering overview course for engineering and design students in the Product Design and Engineering (PD&E) Program at MSDE. The course material will provide the students with the basics of sustainable/green product design philosophy, knowledge, processes, technology, innovation, thinking, strategy, management and skills, and will cover overall sustainable/green product design and development methodologies and bestpractices. Emphasis throughout the course will be on Design for Sustainability (DfS), Design for Environment (DfE), and Green Design & Engineering (GD&E). The course will move from general DfS/DfE/GD&E philosophy and principles to practical PD&E applications for designing green high-technology products. Key issues for the course will be Whole System Design and Analysis and Total Product Lifecycle Design and Analysis as applied to Green Product Design. Sustainable/green products and sustainable/green product design and engineering are key issues in today's world of declining global natural resources. Being able to design and engineer sustainable/green products using, for example, renewable materials and low-energy processes, is now one of the most important factors in new product development. Included in the course will be the tools, resources and attributes for competent green product design and engineering. The course will utilize hands-on design projects and case examples related to the course material. This course will be based on Instructor-delivered lectures and coaching of best-practice fundamentals that can be applied in any situation where innovative green design solutions are required. The Instructor will present topical lectures of principles, tools and processes with examples, visuals and case studies, and then launch related student mini-projects.

The brief course schedule is listed as in the followings:
Session 01: Course Introduction and Syllabus Review
Session 02: Introduction to Sustainable/Green Design
Session 03: Green Product Design Practice, Thinking and Background
Session 04: Green Product Lifecycle and Whole System Analysis and Design
Session 05: Science and Technology for Sustainability and Green Design
Session 06: Renewable and Biodegradable Materials for Product Design
Session 07: Cradle to Cradle Recyclability, Reusability and Reformability
Session 08: Manufacturing Methods and Processes for Sustainability
Session 09: Simplicity and Reduced Complexity of Green Products
Session 10: Platform and Modularity/Upgradability/Service Design of Products
Session 11: Size and Weight Reduction of Sustainable Products
Session 12: Fastening, Joining and Assembly for Sustainability
Session 13: Durability and Long-Lasting Product Planning
Session 14: Toxic and Harmful Materials and Processes
Session 15: Green Energy Conservation and Power Generation

Fig. 3 shows an example, a speaker for mobile phone, of student project results made in the course of DVSM.

Figure 3 A case example of GPDD product design (speaker for mobile phone, [Dresselhaus 2011])

3. Discussions

The current design educations for engineering students in Korea has mainly focused on 'capstone design' partially supported by the University through the "Specialty Curriculum Development Program" funded by the Ministry of Education, for nurturing qualified engineering students. Since designers and engineers usually have not closely worked together, however, the design-engineering link is likely to be the most fragile and their weak collaboration still poses a significant problem even in the academic setting as well as work environments in industry.

The paper addresses an issue of setting a new standard of engineering education by development and support of competitive education curriculum for specialized and innovative design education. This new education paradigm not only provides competitive engineering human resources to the industry but can be also fully utilized as practical case studies of new curriculum strengthening the engineering students with the industrial design skills and design inception, which enables those students to be more eligible for collaborating with industrial design community.

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