

2007: PRODUCT DESIGN FOR INDUSTRY: THE NUS EXPERIENCE

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Product Design for Industry: The NUS Experience

Abstract

The Department of Mechanical Engineering (ME) at the National University of Singapore (NUS) has evolved a curriculum where design is integrated vertically in its undergraduate program. The goals and objectives of the design-centric curriculum are to expose students to the total design process early in their programs of study, and reinforce design problem solving skills at every stage. In this paper, the rationale for moving into a design-centric curriculum for the NUS's ME Program will first be presented. Details of the Industry-sponsored Design Project Program will then be described, including the methodology of project solicitation, how to resolve related Intellectual Property issues with industry sponsors, the allocation of projects to students and the method of assessment adopted. The desired educational outcome for this Program will be presented. Some thoughts and experience on how this Program could be improved for subsequent batches of NUS ME students will also be shared.

Introduction

Design is essentially to do with the creation and transformation of ideas and concepts into a product definition that satisfies customer requirements and expectations. The role of the design engineer is the creation, synthesis, iteration, and presentation of design solutions. The profile of a good design engineer is one who has an innovative aptitude, is an effective communicator, has strong visualization skills, a sound fundamental knowledge of physical and mechanical characteristics of materials, has a good appreciation of fabrication and manufacturing techniques, an acute structural sense and familiar with analytical techniques, is highly disciplined with an ability to balance between technical requirements, cost and schedule, and to verify the integrity of the design.

In Singapore, several government agencies, including the Economic Development Board, International Enterprise (IE) the Singapore, and Singapore Productivity and Standards Board, have emphasized the paramount importance of design for the next phase of Singapore's economic development. Having our graduates appropriately exposed to the full cycle of design will give the Singapore industry a competitive edge. A recent study commissioned by IE Singapore¹ indicated that the output of the design cluster in Singapore amounted to \$3.9 billion in direct contribution to GDP, with another \$3 billion in indirect contribution, and \$2.7 billion in value added, or a total of 1.9% of GDP. Another joint IE Singapore-National University of Singapore (NUS) study estimated that the Singapore design industry has an output multiplier of 1.76, compared to 1.4 for banking and 1.47 for IT. Singapore is moving to become the test bed for pilot-runs and trials for new product launches into Asia and beyond. Multi-national companies such as Delphi Automotive, HP, Motorola, Seagate, Canon, and Philips are constantly introducing new designs here for mass production. As Singapore industries embark on higher value-added activities to remain competitive, more design functions are expected to be undertaken by local companies. Thus, tertiary institutions in Singapore will have an important role to play in design education and training to support the design-focused industry.

Industry-sponsored Design Project Program

Responding to the need to better prepare its graduates for the new landscape where design has a more important role to play, the Department of Mechanical Engineering (ME) at NUS launched a new Industry-sponsored Design Project Program in 2005. The primary objective of this Program is to give ME students the opportunity to gain first-hand experience of the engineering design environment as found in industry today. Students will be exposed to technical proposal preparation, conceptual design, engineering analysis and design, computer-based analytical tools, design documentation, prototyping and testing, problem solving, and quality assurance procedures. In addition to tackling the technical problems, students will also have to learn to deal with non-technical issues such as time management, scheduling, costing, team co-ordination and team dynamics, formal presentation and informal communication, and professional ethics relating to matters such as the use of intellectual properties.

These design projects generally have an industry sponsor each, and require students to work in teams and interface with their sponsors. The design projects would generally result in a component, a subassembly, a finished product or a system for the industry “customers”. All third-year students are required to take these two-semester-long design projects. Each project will be jointly supervised by a faculty member and an industrial mentor throughout the 8-month period from August to April. In the first year of implementation, each project was undertaken by a group of 10 or more students. The group size was reduced to six or seven in the second year because it was observed that the larger group size invariably led to some students not contributing meaningfully to the project.

In the first year, we had 12 industry sponsors who are in the fields ranging from consumer products, defense, electronics, contract manufacturing, automotive to maritime industry. A total of 28 project offered by these 12 partners were allocated to nearly 300 ME students. In the second year (the 2006/07 academic year), 22 companies (Fig. 1) participated in this Program offering a total of 37 projects to some 250 students.



Fig.1. Companies participated in the NUS Industry-sponsored Design Project Program

In our first year of implementation, the allocation of projects was based on a first-come-first-served principle. It ended up with students queued up overnight trying to secure their preferred projects. This was most encouraging as it demonstrated the enthusiasm of students for this new Program. A more systematic allocation process was developed and implemented in the second year of the Program. This computer-based signing-up system requires each team to bid for their preferred project on-line. If there are multiple bidders for a particular project, the bidding teams will have to make a presentation each to a panel comprising members from the company offering this project. The company will then decide which team gets the project. This has proven to be an effective way of project allocation.

These design projects generally require students to interface on a regular basis with their industrial mentors from sponsor companies and faculty member from the Department. This will ensure timely advice be provided to the students. At the end of each semester, students would be assessed both on the reports submitted and presentations made. In addition, students were asked to carry out a peer review and the results of which would be taken into consideration in the assessment. The final grades would be arrived at by both the industrial mentor and the faculty member supervising the project. This should provide a good level of objectivity in the assessment process. Fig. 2 shows one student group in discussion with their company mentors at NUS and the final presentation at the sponsor company premises.



(a)



(b)

Fig. 2. (a) Students' discussion with supervisors; (b) project presentation in company

Training of Design and Development Process

The training of mechanical engineering undergraduate fundamentally covers the aforementioned skills and knowledge required of a design engineer. However, it is generally felt that there is a need to provide an integrated approach to challenge and stimulate these students to apply what they have learned and seek the required additional information or knowledge to solve design problems. In the early stage, ME students in NUS are introduced to the basic design process, manufacturing processes and software tools and computer-based techniques, such as CAD and CAM. In this new Program, students will focus on paper design during the first semester, while in the second semester they will focus on verifying their design through the building of a workable prototype.

To equip students with sufficient practical hands-on experience, ME students will be trained to operate conventional and CNC machines in the NUS workshops. Some of the facilities used by the ME students are shown in Fig. 3. A Design Studio equipped with advanced 3D design, modeling and analysis software, high-powered computing servers and workstations, and rapid prototyping and tooling facilities is also available for students to use. This Design Studio has become the regular “meeting place” for many students and their mentors.

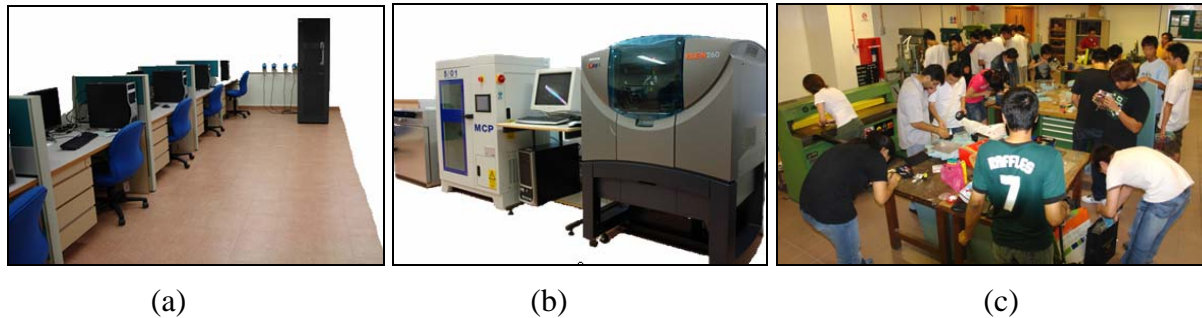


Fig. 3. (a) Computing cluster, (b) rapid prototyping and tooling machines, and (c) fitting and assembly of prototype in the NUS's Workshop

Integration of Engineering and Industrial Design Team

The design activity is now usually shared by a number of professionals, including engineering, manufacturing and industrial design people, who are skilled in the application and management of design processes. Engineering designers are expected to be creative and to be technically competent² (“*Engineering designers are imaginative, realistic and optimistic.*” – Lewis and Samuel, 1989); while industrial designers are particularly skilled at generating conceptual sketches and iconic models which describe the formal, semantic and aesthetic properties of consumer products including the ergonomic variables relevant to the product design interface³. In the second year of the Program, students from the Industrial Design (ID) Program at NUS joined ME students in the Industry-sponsored Design Projects Program. These ID students, from the NUS School of Design and Environment, bring with them their unique perspective of industrial design. They not only give aesthetic view to the design, they also considerably enriched the learning experience of ME students. The ME program is now exploring the possibility of having students from the other engineering disciplines join this Program in the future.

Managing IP and Other Related Issues

Intellectual property (IP) tends to be a sensitive issue for industrial sponsors, although the outcomes from this Program are usually not expected to lead to major breakthrough which would have significant commercial implications. Still, some companies do have expectations of possible exploration or commercialization of the ideas developed through this Program. It is natural for the sponsors to request for ownership of the IP after the project completion. We have been able to work with our University Industrial Liaison Office to develop customized IP agreements to suit their needs in addition to the standard one which is usually on the basis of co-ownership. However, some sponsors, especially the more established companies, tend to prefer to solely own the product IP with an understanding of a mutually-agreeable royalty payment

scheme. We are glad to report that we have been successful in having customized IP arrangements which satisfied the needs of all our sponsors.

Other issues we have encountered in running this Program include the management of companies' expectation, student workload and project assessment, workshop safety, students' peer review, budget control, solicitation of following-up projects. We have learned much through the two years of running this Program.

Preliminary Feedback from Students and Industry

Through such industry-sponsored design projects, NUS ME students will have the opportunity to gain precious first-hand experience of keeping tight timelines and meeting exacting targets-demands which they will have to face when they join the industry. Many of our sponsors also used this opportunity to spot potential talents who could join the companies upon their graduation. We see this as a win-win situation for all parties involved.

Feedbacks from sponsors and students on this Program have generally been positive. Some of the comments from students include: *"we gained valuable insights into real world situations and real world problems."*; *"It gives me a greater sense of satisfaction knowing that my studies can be put to practical use."*; *"this project has given me insight into the practical significance of the subjects we studied, ...I learned about the human aspect of design and the importance of leadership and people management."* One of our sponsors commented: *"[we are] very impressed by the understanding and design ideas the ME students have come up with. Some of the ideas are very good and worthwhile to be explored and investigated further."*

Conclusion

With design being considered to play a significant role in the next phase of Singapore's economic growth, mechanical engineers with a good appreciation of the full design cycle and associated issues will have an advantage. They will certainly be highly sought after by the industry. This desire to produce mechanical engineering graduates with a good grasp of design led to the Industry-sponsored Design Project Program which was launched in 2005. The primary objective of this Program is to give NUS mechanical engineering students the opportunity to gain first-hand experience of the engineering design environment as found in industry today. Since its launch in 2005, this Program has received an overwhelming response from the local industry. A refinement to this Program was more recently introduced whereby students from the Industrial Design Course (at the School of Design & Environment, NUS) were invited to join the project groups, working on the design problems together with mechanical engineering students. The interactions of the two different perspectives each group of students brought to bear on the projects not only led to a much richer learning experience for all, it has also resulted in some interesting solutions to the design problems these student groups have to solve. As the Program looks to its third year of implementation, it will continue to reinvent itself, seeking better ways to provide an even better learning experience in design for NUS Mechanical Engineering undergraduates.

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