INTRODUCING INDUSTRIAL DESIGN TO THE STUDENTS OF RENAISSANCE ENGINEERING PROGRAMME: A PERSONAL EXPERIENCE

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ABSTRACT
Nanyang Technological University (NTU), Singapore, founded in 1991, is amongst the largest engineering universities in the world. NTU offers an integrated engineering programme that admits about 50 elite students, awarding a dual-degree comprising of Bachelor of Engineering Science degree and Master of Science in Technology Management. Called the Renaissance Engineering Programme (REP), this is a rigorous 4.5-year programme with a curriculum that intends to bridge engineering, business and the liberal arts which includes design. The intention is that the REP graduates would master and possess the necessary knowledge, skills and attributes within the broader context of engineering science to become future leaders.
During the second year, REP students take a compulsory module titled *RE8007 Aesthetics and Design in Industry*, which gives the students an idea of the importance of aesthetics and the relationship between form and function and how user experience can influence industrial design decisions. As the instructor of this module, the author experienced first hand, how REP students cope with abstract concepts, the creative process and execution methods of industrial design. This paper candidly discusses the issues of teaching industrial design to engineering students with an expectation that, together with what they gain from other engineering design modules, the students will possess the wherewithal to become designers capable of solving complex problems upon graduation. This paper discusses ways to improve the approach to teaching integrated design and how this has panned out in the effort to introduce industrial design to REP students.

Keywords: Industrial design, engineering design, curriculum, integral design

1 INTRODUCTION

Nanyang Technological University introduced the Renaissance Engineering Programme (REP) in the year 2011 with the aim to provide an integrated approach to teaching engineering to a carefully selected group of students who are high achievers (top 2%) in their high school leaving examinations (A-Levels or IB Diploma or Polytechnic Diploma or equivalent) and show potential, during selection interviews, to study in a multi-disciplinary programme that is meant to connect engineering, business and arts and social sciences. At the end of four and a half years of study, REP, students are expected to have mastered and 'possess the necessary knowledge, skills and attributes within the broader context of engineering science' (http://www.ntu.edu.sg/REP/Pages/default.aspx). Students admitted to REP study a common programme for the first two years and chose an area of specialisation in Year 3 and 4 in one of the following areas of discipline: Biomedical Engineering, Chemical Engineering, Civil & Environmental Engineering, Computer Engineering, Electrical & Electronic Engineering, Materials Engineering, Mechanical Engineering, and Aerospace Engineering. The highlight of REP is also the one-year of study during the Year 3 at the University of California, Berkley or Imperial College, London followed by an internship in USA or UK.
If the selection of the students is very stringent, selection of 'REP Fellows', the faculty who teach in the REP programme, is very strict, with multiple interviews with the Director of REP programme and other REP Fellows before being admitted to teach in REP. REP Fellows are selected from different colleges and schools within NTU. The author was selected from the School of Art, Design and Media to teach a second year course titled RE8007 Aesthetics and Design in Industry. Taught as a 'seminar'

course, RE8007 aims to 'introduce the REP students with a broad understanding of industrial design and acquaints them sufficiently to work with the creative professionals who influence not only the aesthetics of products and built environments but also the user experience and, to an extent, the manufacturing of such products and built environments'. While the author, a trained industrial designer with a mechanical engineering background, enjoyed teaching the first cohort of 35 students and the second of 56 students, the Student Feedback on Teaching (SFT) from both the cohorts revealed another side of the story. The students revealed some interesting facets to teaching an introductory course on industrial design to an elite group of engineering students, which set the author on a pursuit to understand what needs to be done if such a course is to be taught to engineering students.

This paper looks at four aspects in discussing the experience of introducing industrial design to REP students:

1. What is design as understood by design schools versus engineering schools?
2. What is the expectation on design course(s) taught in REP from NTU versus REP students?
3. Results of student work from 2012 and 2013
4. How could design be taught for a specialised course such as the REP?

The author also takes a small detour to highlight other programmes that are similar to REP in order to compare how design is taught in such programmes.

2 DESIGN IN DESIGN SCHOOLS VS DESIGN IN ENGINEERING SCHOOLS

Design means different things to different people. Sathikh [1], in a paper titled *Mapping design curriculum in schools of design and schools of engineering* highlights the main difference between the understanding of design by design schools and engineering design. Design schools tend to take a generic definition of design at the first level since many of them allow students to specialise in very focused areas of design such industrial design, visual communication, interaction design, etc. Engineering schools, on the other hand, equate design to engineering design with reference to product design and/or industrial design within 'design' modules. This means that there is a clear difference in the accent of design in these two schools, which is reflected in the way the curriculum is developed by the two schools. Sathikh [1] has compared the typical curriculum for undergraduate programmes in industrial design and engineering that can be summarised as:

- Industrial design lays more emphasis on use and function with reference to the final user, in what may be termed user centred approach to design.
- There is greater emphasis to subjects that sensitises students to aesthetics and emotional aspects of products/objects within the built environment.
- Engineering design curriculum lays more emphasis on use from the viewpoint of function drivers or component and system elements.
- Engineering design curriculum is interested in teaching the students about optimising such function drivers for efficiency, manufacture and cost with little attention to emotional aspects of design.

This is corroborated by the definition for industrial design from NASAD, National Association of Schools of Art and Design (http://nasad.arts-accredit.org/) and the definition for engineering design from ABET, Inc., the recognised accreditor for college and university programmes in applied science, computing, engineering and technology in the USA. NASAD states that 'industrial design involves the combination of the visual arts disciplines and technology, utilizing problem-solving and communication skills' while ABET defines engineering design as **'**the process of devising a system, component, or process to meet desired needs'. All this points out to two distinct professional aspirations that need to work together for successful design of products allowing space for each other, which means that one has to learn some aspects of the other to build a harmonious process of product development.

3 EXPECTATIONS OF DESIGN COURSES IN REP

It is important to look at the first two years of study at REP since this represents the multi-disciplinary study period before the students embark on the area of specialisation and head off for their study year to USA or UK. There are practically no course modules on design during Year 1 of REP. In Semester 1 of Year 2 there are two key courses on design, namely Build and Test Project and Aesthetic and Design in Industry. In Semester 2 of Year 2 there are two more course modules that are design related,

namely Integrated Design Project and Design and Systems Engineering. The expectation from REP management was that, by the end of Year 2, students must have the wherewithal to design and develop a whole range of products and services with due considerations to aspects of industrial design and engineering design including material, costs, manufacture, marketing, etc. That is a tall order, if one is to consider that there were no introductory or foundation modules, neither in industrial design nor in engineering design. This is in addition to the large workload from traditional mathematical and engineering subjects that are compulsory for Year 2 students.
Being high achievers, REP students take up the challenge to read up on what is being taught. In understanding abstract concepts associated with aesthetics and design, however, REP students seem to have difficulties. This handicap is further magnified when they need to continue with Design and Systems Engineering and Integrated Design Project in the following semesters, during which time, REP students are expected to learn CAD skills on their own, which adds to the difficulty of taking design forward. It is in this context the author experienced, first hand, the challenge of teaching Aesthetics and Design in Industry for the first two batches of REP students.

4 EXPERIENCE OF TEACHING AESTHETICS AND DESIGN IN THE INDUSTRY FOR THE FIRST TWO BATCHES OF REP STUDENTS

The first batch of REP class had 35 students while the second batch was significantly larger, consisting of 56 students. Placed between a studio/seminar class and a lecture format, the Aesthetics and Design in the Industry class, with three contact hour per week for a total of thirteen weeks, had to be meticulously planned with lectures, video screening, class assignments, visits and projects for every week. Students were clearly told that this course introduces them to industrial design and is meant to familiarise them with the field so that they will be ready to work with designers in their working life. The course started with a trip to IKEA megastore located at Tampines in Singapore. This trip was to expose the students to Scandinavian furniture and aesthetics and to point them to the need for building simplicity through design. A series of lectures supported by class exercises, which utilize information and visuals from the Internet were employed to keep the students occupied. Just after the mid-semester break students were taken to Red Dot Museum in Singapore, followed by a visit to ‘Courts’ an electric/electronics supermarket. The last six weeks were lectures that gave an idea of the relationship of design with different facets of product development. These lectures were supported by presentation of real life experience from the author as well as selected guest lecturers. The author also brought with him actual samples of finished products as well as material samples to show the students. Students were asked to write a term paper on a subject related to design and were asked to design a poster on this term paper. These posters were displayed and each student was asked to vote for their choice based on criteria of graphic design layout. The whole process of voting became an interesting event by itself.

4.1 How was the course received by REP students

The author felt comfortable with the mode of teaching and the response he was getting from the class. Field visits were well received with enthusiastic students following every aspect that the instructions had asked them to observe. Assignments were submitted on time and they were well written. All the indicators were pointing to a successful class. But, when the Student Feedback on Teaching (SFT) was handed to the author for the first time, it was a complete shock!
In both the years, there were only about 30% of students who enjoyed the course, while another 30% were neutral about it. The last 40% of students however, were very critical of the course and the way the course was conducted. Comments ranged from ‘this module was boring’ to ‘the course was not structured properly’ to ‘the instructor did not show us how to design’. There was even a comment that ‘the instructor got away with showing YouTube video clips’. The clips shown were taken from YouTube and other sources, and were usually conversations with designers such as Jonathan Ive of Apple Computers or were from IDEO or were from injection moulding manufacturers themselves, etc., and all were highly relevant. The SFT results for the other three design related courses did not fare any better, with comments such as ‘these courses are not relevant’ or ‘was not presented properly’. To the REP Fellows, who were used to being graded high for their teaching in their respective departments, this came as a surprise. What were the reasons for such a review then? What can be done?

5 DISCUSSION

In order to understand what could be done better to improve student acceptance of an introduction to industrial design in REP, the author looked for similar specialised or elite undergraduate courses in engineering. A paper written in 1995 titled *THE LEARNING FACTORY - A new approach to integrating design and manufacturing into engineering curricula* [2] caught the attention of the author. Started as a project under the Manufacturing Engineering Education Partnership (MEEP) brings consisting of engineering programmes in Penn State, University of Puerto Rico- Mayagüez, University of Washington and Sandia National Laboratories, the Learning Factory aimed to provide 'A practice based engineering curriculum which balances analytical and theoretical knowledge with manufacturing, design, business realities, and professional skills'. The original curriculum build up of the Learning Factory, as envisaged by MEEP is shown in Figure 1., where the foundation to this curriculum is ' Product Dissection, Graphics and Design'. Reading the paper in detail, reveals that during the foundation phase the students 'examine the way in which products and machines work: their physical operation, the manner in which they are constructed, and the design and societal considerations that determine the difference between success and failure in the marketplace. In other words, students need to spend some time to 'dissect' the design elements of existing products in order

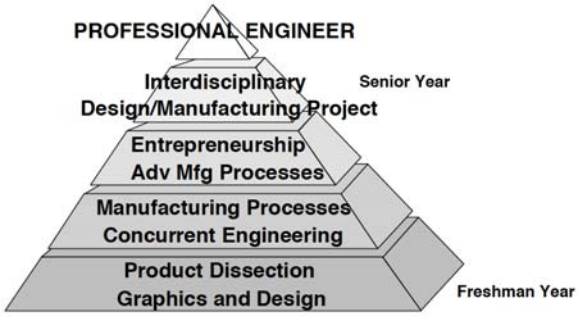

Figure 1. Curriculum build up from the Learning Factory

to understand the relevance of industrial design and engineering design to the overall validity of the products. The Learning Factory today seems to be a part of Penn State as a centre where students can do 'industry-sponsored and client-based capstone design projects' (https://www.lf.psu.edu).

Dissecting products for design and engineering elements does not necessarily give the educational basis for understanding industrial design. Green et al [3] in an article titled *Studio-based teaching: history and advantages in the teaching of design* point to an important element in the teaching of industrial design, namely, the studio, which they (eschewing the ideals of Walter Gropius) point out 'should be a place where studio projects were executed and these should reflect professional practice. The adjunct courses, such as mechanics, manufacturing and materials science, should not be isolated from the project activity in the studio, but rather be complementary to it'. This could be difficult given the context of contemporary engineering education. In REP's case, the idea of a studio-based education seems reflect in the classroom environment where students are clustered into 'desk islands' and are provided with multiple projections, on-line interactivity and other hi-tech accessories. A curriculum structure such as the Learning Factory and conducive classroom environment as in REP alone may not ensure that students will grasp abstract concepts associated with design.

Sathikh [1], in discussing integrating industrial design and engineering design proposes a hybrid model, shown in Figure 2, where the essentials for both fall within the intersection of the Venn diagram. In the author's opinion the course modules that fall within the common area may form a structure for building the essential skillsets and knowledge in design that will be required by students of REP. The other possibility is a combination of what is stated in Figure 1 and Figure 3 which then will allow for the teaching of an integral design curriculum where student get to understand industrial design and engineering design before working on complex projects requiring design. This process can be further enhanced if complex projects are undertaken by REP students together with the (industrial) design students from the School of Art, Design and Media at NTU. In this way both REP and design

students can contribute to a successful implementation of integral design projects within each other's curriculum.

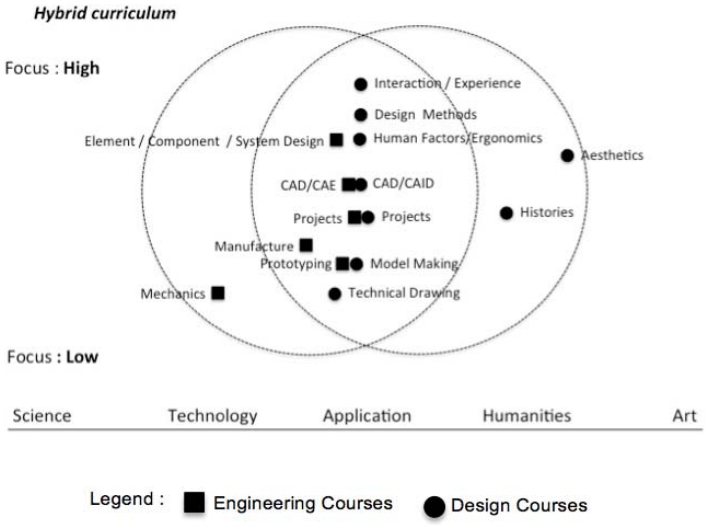

Figure 2. Hybrid curriculum model

Author's' experience of teaching design in schools of design and schools of engineering in the past shows that selecting the topic or course modules, as in Figure 3 and putting them in the structure of the Learning Factory (Figure 1) without a teaching structure and trained/experienced instructors produce a fall back effect to the 'lecture-tutorial' model where the students receive 'canned' goods through lectures which are then verified through tutorials. What could be a possible pedagogy model for REP then?

While the studio-based learning proposed by Green et al [3] seems to fit teaching methods in industrial design and has been the practice of many art and design schools around the world, teaching the concept of industrial design or a hybrid course of Figure 3, there needs to be a level of rigour in terms of introducing the theoretical elements of design followed by design problems that the students could possibly complete. This differs from the open-ended, project based approach taken by most of the design schools. Preparation requirements can also be introduced where students are asked to read and do online research about the project that is going to be introduced. Atman et al [4] in an article titled *Teaching Engineering Design: Can Reading a Textbook Make a Difference?* have studied this possibility as early as 1996 and have found that 'subjects that read the design text before they solved the three open-ended problems spent significantly more total time working on the problems, generated more alternative solutions, iterated significantly, more often through steps in the design process, and considered significantly more design criteria as they developed their solutions to the problems than did subjects that did not read the text before solving the problems'.

To summarise a possible approach to restructuring the teaching of design to REP :

1. Revise the curriculum and syllabus based on the built-up suggested by the Learning Factory [2].
2. Identify key components to teach based on the hybrid model presented by Sathikh [1].
3. Keep the studio environment already in place.
4. String the theory and practice together through a problem based approach.
5. Instead of a complete open ended approach, present the theoretical aspects and general constraints of the problem at hand.
6. Give students tasks to do in terms of reading and researching before hand.

Being high achievers, REP students may prefer the revised design modules better than the way they were presented in the first two years. Was it possible to execute this?

6 CONCLUSION

In trying to understand what did not go well in offering an introductory course on industrial design to the students of the Renaissance Engineering Programme, the author, together with the other instructors

teaching design modules, were able to identify that there needs to be a revision of the curriculum to offer a series of modules culminating in integral design within REP. The first step to interest REP into this integral design could be the 'product dissection, graphics and design' approach proposed by the Learning Factory. In author's opinion before such revised approach could take place, faculty from engineering and design needed take the necessary steps to understand each other's contribution in the integral design curriculum so that the students will enjoy studying design as part of REP.
The first step towards such integration has already been taken at NTU by the Director of REP who had merged the four design based courses into a series of two modules where REP Fellows who were teaching each of their parts separately were asked to string together the design modules and teach as a team. The first of such integrated approach has already been tested with the team teaching approach in Semester 1 of academic year 2014-15 and the Student Feedback on Teaching (SFT) for this new module from the third batch of REP has been more than encouraging pointing to a right direction in teaching design to REP students.

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