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APPROACHES TO TEACHING PRODUCT DESIGN TO ENGINEERING STUDENTS

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ABSTRACT
3D computer aided design (CAD) and 3D printing seems to have developed to such a degree that the students in engineering courses are made to believe that they could attempt to design all aspects of a product. Mastering the total aspect of product design and development may take a significant part of one's career. In an earlier paper, the author put forth a need for degrees that are hybrid, which may represent the real world nature of design in the built environment today. Such a programme is offered at a master's level in several universities in the world, mostly as collaboration between design, engineering and business units of that university. While hybrid undergraduate programmes that combine aspects of design and product development engineering, may take a while to be offered, there needs to be an intermediate solution to help set the tone for successful product design courses at a bachelor's level for students of engineering. This paper touches on a framework for hybrid degree programmes to benefit students who are keen to be engineering designers, and describes the author's experience in team teaching a product design module, for the first time, to year 4 students of the Design Stream from the School of Mechanical and Aerospace Engineering at the Nanyang Technological University in Singapore. The paper concludes with a discussion on the author's views of teaching the course in industrial design for engineering students.

Keywords: Product design, product development, hybrid programmes

1 INTRODUCTION

Teaching of engineering at a bachelor's level far outdates the teaching of product design or industrial design as a profession. Several references cite the forming of Corps of Engineers in UK in the last quarter of the 18th century and in the US in 1825 as the foundation for the formation of engineering education, though there is evidence that engineering, especially civil engineering, was taught in many forms much earlier than those dates. Teaching of design, as we know it today, starts with the famous Bauhaus founded in 1919 by Walter Gropius according to Sathikh [1]. Proclamation of the Bauhaus of 1919 described a utopian craft guild combining architecture, sculpture, and painting into a single creative expression which combined fine art with design education to turn out artisans and designers capable of creating useful and beautiful objects appropriate to this new system of living. Ulm School of Design in the mid-1950s redefined design, not as a 'superior art' but as a process that integrates science and technology within it, defines the school itself as, 'an international centre for teaching, development, and research in the field of designing industrial products'.[1]

Over the years, there seems to be differences about the definitions of the profession of design, with some schools following the traditions developed by Ulm School, Royal College of Art and Design Academy Eindhoven, to name a few, while other schools tend to approach product design education differently. What does this mean to product design education itself? This paper brings out the thoughts of the author, trained in both engineering and industrial design, with regards to the need to teach the essentials of product design to students of mechanical engineering.

[1] http://www.hfg-archiv.ulm.de/english/the_hfg_ulm/history.html

2 OVERVIEW OF DESIGN IN EDUCATION

In a paper titled *Engineering Design Thinking, Teaching, and Learning*, Dym et al [2] define engineering design as. 'Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints.

ABET, which accredits education programmes in applied and natural science, computing, engineering and engineering technology. Under *General Criterion 5: Curriculum*, ABET[2] defines engineering design as, '...the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

The Industrial Designers Association of America (IDSA)[3] defines industrial design as, '...the professional practice of designing products used by millions of people around the world every day.

Industrial designers not only focus on the appearance of a product, but also on how it functions, is manufactured and ultimately the value and experience it provides for users'.

NASAD, the accreditation body for programmes in art and design, in outlining the essential competency required for industrial design[4] states, 'Ability to design products and systems, including but not limited to a foundational understanding of how products and systems are made; what makes them valuable; how they are developed, realised, and distributed; and how they are related to environmental and societal issues and responsible design'.

In order to make a sense of these definitions, key words are picked out and laid out in Table 1 for easy comparison. Table 1 reveals very few common words between the definitions of engineering design and industrial design; system, function and manufacture (made). While engineering design explicitly mention needs, industrial design seems to wrap this under, value and experience. The word, form, appears in Dym et al's [2] definition while IDSA mentions appearance. This revelation perhaps, is obvious in the way the subjects are taught in each of the schools. Sathikh [3] attempts to show this in in Figure 1.

Table 1. Keywords of engineering design and industrial design

Institute/Paper	Engineering Design	Industrial Design
Dym et al [2]	1. systematic/ intelligent process 2. generate, evaluate and specify 3. devices, systems or process 4. form and function 5. objectives or needs 6. constraints	
ABET	1. decision making process (iterative) 2. system, component or process 3. needs 4. basic sciences, mathematics, and the engineering sciences 5. resources	
IDSA		1. design products 2. appearance 3. function and manufacture 4. value and experience
NASAD		1. design product and systems 2. how they are made 3. value 4. environmental and societal issues 5. responsible (design)

[2] www.abet.org
[3] http://www.idsa.org/events/what-id
[4] https://nasad.arts-accredit.org/wp-content/uploads/sites/3/2015/11/BFA-IndustrialDesign.pdf

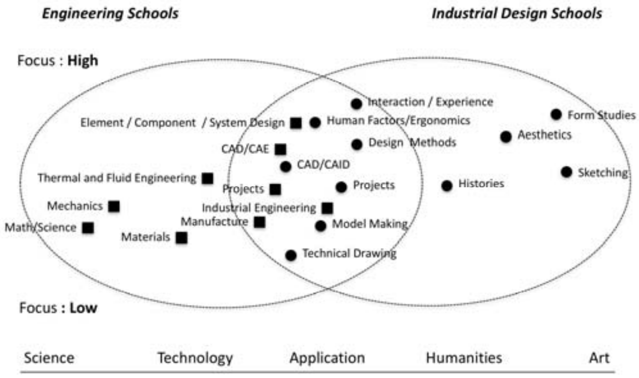

Figure 1. Curriculum in engineering schools and design schools [2]

Figure 1 shows that an engineering curriculum covers a range of subjects from science through technology till application, while industrial design curriculum covers (from the right) art, through humanities, till application. While the overlap, as seen in Figure 1, is in the realm of application, engineering design approaches product design from the science end of the spectrum, while industrial design approaches it from the art end. Can there be a middle ground then?

3 HYBRID DESIGN CURRICULUM

Are there programmes where both are taught together? While undergraduate degrees in industrial design engineering is being offered in several European universities such as The Hague University of Applied Sciences in the Netherlands and Swinburne University in the UK, there is a need to introduce product design from an industrial design perspective to students of engineering (design). Sathikh [2] proposed a hybrid curriculum for undergraduate education as shown in Figure 2.

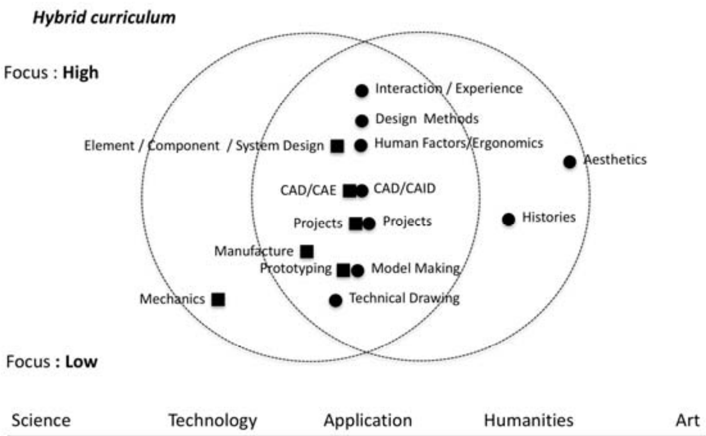

Figure 2. Proposed hybrid curriculum in product design [2]

Sathikh [3] argues that graduates from such hybrid programmes would have, ‘strong application knowledge and project management skills together with sufficient peripheral knowledge in areas related to art and engineering’. Sathikh [3] also proposes that hybrid designers will be able to contribute to innovation aspect of design especially, ‘Products requiring new paradigm in user experience and application of technology...’. Does this mean that all universities should be planning for hybrid programmes in product design? What is the basis on which product design be introduced and accepted within a standard engineering curriculum?

4 AN APPROACH TO INTRODUCING PRODUCT DESIGN

There are two aspects to introducing product design to engineering students at undergraduate level, which the author feels are important: 1) The appropriate position within the curriculum structure of the engineering programme when the subject is taught and 2) How the subject of product design is taught to the students of engineering.

4.1 When to introduce product design?

An idea of when to introduce product design is revealed by Lamancusa et al [4] in the 'Learning Factory' initiative shown in Figure 3 where 'Product Dissection, Graphics and Design' is introduced at the freshman year, making product design a core subject at the very early stages of study, where the subject maybe introduced too early to be effective. Hence, there may be a need to offer product design as an elective at the senior year as a follow up to what students learn in the freshman year.

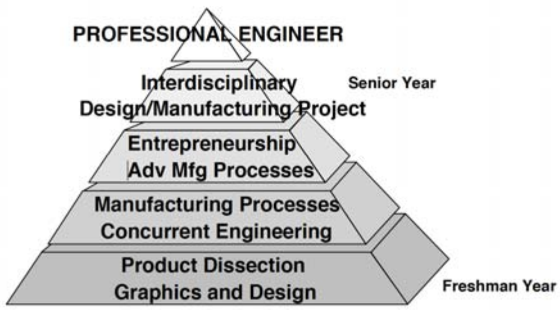

Figure 3. Curriculum structure at the Learning Faculty [4]

4.2 How should product design be taught?

Design education, is usually built on the framework of studio based learning. This is corroborated by Green et al [5] who state, '...the modern-day studio includes not only a principal focus on the aesthetic but also upon usability, sustainability and design for manufacture'. Studio based learning is also mentioned as a part of the Learning Factory, where product dissection is realised through various means within the Learning Factory, of which is the design studio as seen in Figure 4.

Having design studio alone may not suffice for product design to be taught effectively, the method of teaching is equally important. Mills et al [6] propose project-based learning as an effective method, citing advantages over others such as; project tasks are closer to professional reality; project work is more directed to the application of knowledge; project-based learning is usually accompanied by subject courses (eg maths, physics etc. in engineering); management of time and resources by the students as well as task and role differentiation is very important in project-based learning and self-direction is stronger in project work.

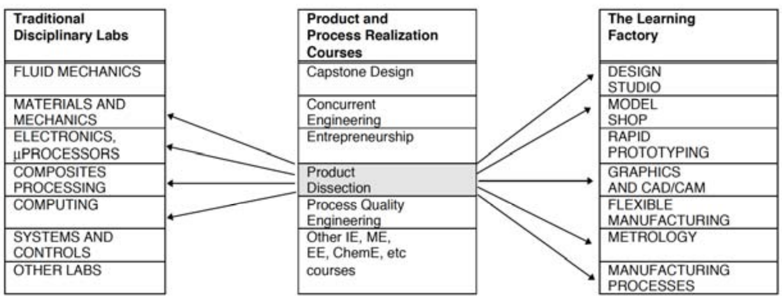

Figure 4. Realisation methods in the Learning Factory [4]

Could product design be taught to engineers through project-based learning in a design studio setting? Is there an opportunity to test the effectiveness of such approach within a university which has a school of engineering and a school of design?

5 MODULE ON INDUSTRIAL DESIGN

The School of Art, Design and Media (ADM) and the School of Mechanical and Aerospace Engineering (MAE) at the Nanyang Technological University (NTU initiated a module on industrial design to be offered to MAE's design specialisation students. Team taught by a faculty each from

ADM and MAE, it was offered for the first time during semester 1 of academic year 2017-18 with sixteen final year students of design specialisation from MAE.

5.1 Studio, faculty and the curriculum

The product design studio at ADM provided the class setting for this module to introduce the students to design studio this also allowed the students to access the workshop facilities at ADM. The team consisted of two faculties from ADM and MAE each. The curriculum was carefully crafted to take advantage of ADM's strength in teaching product design.

5.2 Project-based learning

From the outset, it was decided that this module would be project-based with a live project from a client who offered an existing in-car air purifier with a brief to design a contemporary model with importance appearance as well as interaction. The final outcome was to be full sale mock-up models supported by a slide presentation, poster and a two minute video.

6 THE PROCESS AND OUTCOME

The students, were surprised at how a design studio helps them to step out of their comfort zone and realised that there were no right or wrong answers, but only design solutions that are more appropriate than the others. Students also learnt quickly from ADM students on design methods and utilised the model making facilities available at ADM and MAE. Final presentation was held in mid-November 2017, with the some of the results surprising the instructors as well as the client. Figure 6 shows selected mock-up models and Figure 6 shows selected posters that were displayed at ADM.

Figure 6. Final Mock-up Models

Figure 7. Posters

7 DISCUSSION AND CONCLUSION

As a first level experiment in offering a product design module to students of mechanical engineering, in a design school settings, this course has been a success and sets some milestones for future courses of such nature in NTU. Still, the way this course is offered may be improved. After informal discussions with the students, the author has identified several ways this module may be improved when offered in the next academic year:

1. There may need to be a simple selection process to ascertain potential students' aptitude to taking this module. This will help steer the course in a more meaningful way.
2. The number of lectures may be cut, perhaps, to half. This is from feedback from the students that many of the theoretical and philosophical frameworks they could study on their own.
3. Adopt ADM's style of one to one review and group critique on a regular basis.
4. Take the students to electronic supermarts and museums such as the Red Dot Museum within Singapore to familiarise the students to contemporary trends in product design.
5. Organise a day of seminar, inviting design practitioners present and talk about design and their work.
6. Offer the possibility for those who have done well in the module to take up a year 3 level product design core module offered to ADM students.

This would be an approach the team plan to take while offering the course during semester 1 of academic year 2018-19. While a total hybrid programme as described earlier in this paper would be the ideal approach, there is a need to roll out course on product design which allows engineering students to have a hands-on experience in a design school environment. The author looks forward to seeing many such initiatives which will allow for discussions for further enhancements that bring benefits to the student.

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