Innovation by Design – A new post-graduate program at SUTD

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Abstract. Design thinking has been gaining importance in training and education worldwide. However, training and education in design thinking has mostly found a place in short courses and executive education initiatives. Although there is enormous value in short courses and executive education, they often lack the depth required to effectively practice the tools and methods learned. Furthermore, design is a strategic investment for both companies and countries, the particular focus of this paper being Singapore. At the Singapore University of Technology and Design, a new Master of Engineering (MEng) program has been set up to address this perceived gap in education. The MEng program in Innovation by Design (MIbD) is a research-based program that takes design thinking and design innovation to the level of other post graduate programs in other areas worldwide. Three terms into the program, the balance is extremely positive. The program has been very well received in several presentations to companies. It is expected that these students will either start their own business or find jobs easily in a context that is craving for people with this formal education, a very broad view of design, and the ability to implement it.

Keywords: design education; master programs; double diamond;

1 Introduction

Design has become a strategic investment for companies [1] and countries [2] alike. The investment of Singapore in Design has been tremendous in recent years. This investment has led, among other achievements, to the recognition from several experts in Academia of SUTD as an emergent leader in engineering education [3]. However, there is a perceived gap in post-graduate education, which the Singapore University of Technology and Design (SUTD) has tried to bridge with a new Master of Engineering (MEng). The MEng program in Innovation by Design (MIbD) is a research-based program that takes design thinking and design innovation to the level of other post graduate programs in other areas worldwide. It further develops the SUTD design ethos [4,5] toward a post-graduate level. It contains a comparatively reduced coursework load and instead focuses on research and development projects where the tools and methods

delivered in the courses are actively used. The structure of the program is such that there are only three compulsory full-credit courses (green and red in Figure 1) and a significant number of electives (dark blue in Figure 1) that students can take to scaffold their research work. These are complemented by three experiences/accelerators (short, no more than one-week long workshops and seminars, spread around the first year, in light blue in Figure 1).

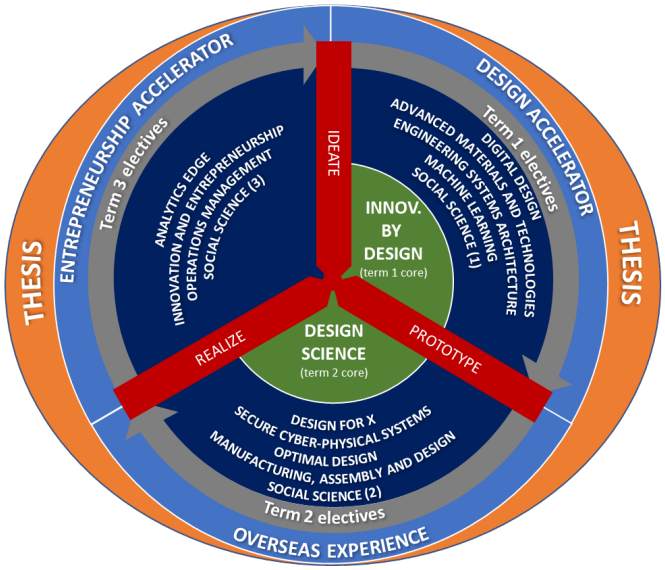

Fig. 1. The overall structure of the MEng in Innovation by Design.

The three experiences consist of

- the design accelerator, a three-day workshop to get all the students up to speed in terms of tools and methods of design and the 4D (discover-define-develop-deliver) design model;
- the overseas experience, an immersion week for co-development with students from other countries and backgrounds (done this year at the School of Design, Jiangnan University, China);
- and the entrepreneurship accelerator, a three-day workshop on how to develop start-ups, IP and business oriented topics.

The first intake of this program was in September 2019. A total of 30 students were selected (20 male and 10 female), 25 being full-time and 5 part-time. 24 scholarships were given, and one student is being supported by his company. The students come from 7 countries (Singapore, Sri Lanka, India, China, Tanzania, Colombia and Indonesia) and have backgrounds in e.g. Robotics, IOT, Chemistry, Materials, Ageing/Healthcare, Drones/UAV, Food Science, Design, Sports, Mechanics, Electronics and Education. This intended diversity in background and culture enriches the learning and design process. By the end of the Master, each student will have

completed a minimum of 5 full-length projects, from discover to deliver. Those taking electives may have done even more. The sections below will describe the various compulsory courses and experiences, what the students have feedback to us on multiple aspects of the program, and what we are planning to do to improve on the program.

2 The compulsory course on Innovation by Design

The first term compulsory course is Innovation by Design. In this course the students work in teams to develop a product/service/system. The classes are about the tools and methods of product design and development [6] covering the 4D's (discover, define, develop and deliver) with a mix of presentations, discussions and studio work for the 12 weeks of class. Students have to find a problem within a broad theme, and solve it. For the first intake, the theme was "Play". Students have to find a problem that is meaningful to them and then solve it through an engaging, playful product/service/system. Each year the problem space will change. Four lessons were devoted to invited speakers from industry to talk about their experience in developing new products, or their work in their respective organizations in fostering creativity and innovation.

3 The compulsory course on Design Science

Th2 second term compulsory course is Design Science. The course introduces students to design science, where many design principles and methods are reviewed, applied and analyzed. Students learn to make connections between design science and other fields (e.g. engineering, architecture, …) and how principles in design science can be used to advance these fields. The class will cover a broad set of design methods such as customer needs analysis, methods in creativity, functional modeling, design for X, design for testing & verification. The curse will further scaffold students to craft their thesis topics using a design research methodology [7].

4 The compulsory thread on Ideate-Prototype-Realize

On the first week of the program, the students are enquired about their research interests, and a match is made between their interests and the appropriate faculty advisor(s). Hence, within three weeks of the program, the students can start right away in their research work. The Ideate-Prototype-Realize thread (I-P-R) runs on the first three terms of the program, lasting a full year. The vision behind I-P-R is to scaffold the students' research with the faculty advisor(s) expertise and embed the student in one of SUTD's research centers, potentially having him/her join an on-going research project. In this way, the student will be part of a team that is already developing research, instead of having to start from scratch. The student-advisor pair will have to craft a research program that takes advantage of the on-going projects and is also

meaningful for the student to learn his/her skills relevant to his/her research interests. I-P-R will link directly to each students' research topic leading to the final thesis. Each student will have his/her own topic, so a complete and detailed set of guidelines is hard to put forth. However, a vision for each term will be the following:

- **Ideate** should be about discovering the topic and proposing potentially innovative ideas about it, through literature reviews, benchmarking, ideation techniques, …;
- **Prototype** would continue for the next term to develop prototypes (or experiments) that embody the ideas or gaps found in the literature, and finally;
- **Realize** would be done in the third term and would conclude the study with some proof-of-concept of the ideas developed and prototyped earlier.

So far, students are hosted in four of SUTD research centers, namely, the SUTD-MIT International Design Center, the iTrust Center for Research in Cyber Security, the Digital Manufacturing and Design Center, and the Lee Kuan Yew Center for Innovative Cities. Some examples of the research projects that each student has been developing can be seen in Figure 2 (others are not shown for reasons pertaining to intellectual property). As of the writing of the present paper, work on "Realize" is starting.

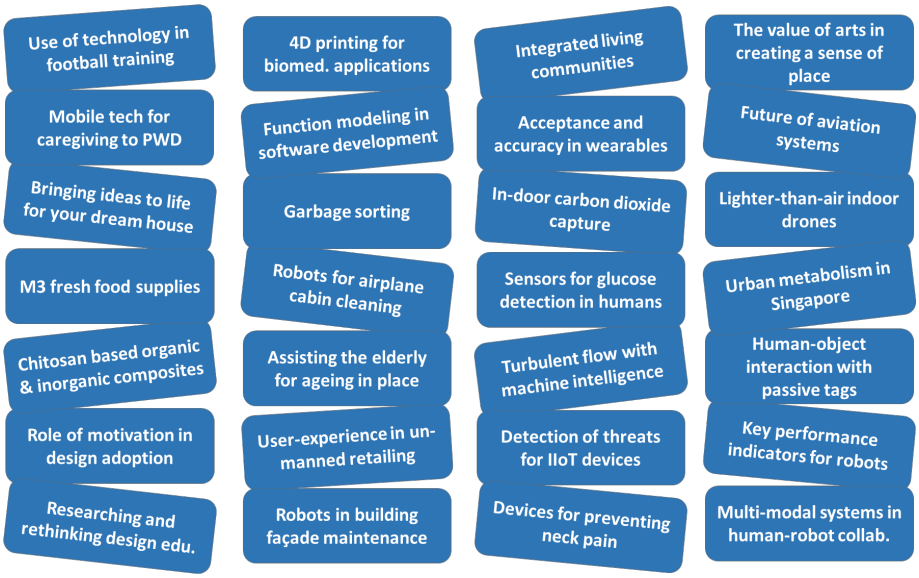

Fig. 2. The research areas of the first year students

5 The experiences and accelerators

As seen in Figure 1, the program contains two accelerators and one overseas experience. The first one is the Design Accelerator, specifically designed as a pre-term learning journey specifically for those which may not be very familiar with design language and processes. During this 2-3 day accelerator, the students work in teams under a theme that changes every year. This accelerator mimics directly the executive workshops that SUTD conducts with companies through the SUTD Academy, and it serves to get the student up to speed with a common basic knowledge of design principles, tools and methods.

The second is the Overseas Experience. This experience sits between terms 1 and 2, after the students have gone through the first term Innovation by Design course. The experience is done overseas, which means the students are all taken to a different venue to co-design (again within a theme that varies for each year) with other students from a different country and background. The co-design experience can last between one and two weeks, and is co-funded by the program. For the first intake, students were hosted by the School of Design at the Jiangnan University, Wuxi, China, for one week, and they were paired with local students of design to solve a problem that was put to them. By the end of the week, all teams had to present a prototype of their solution to the problem. The problem for the first run of the experience was:

> *Design a personal mobility device for the last mile to cater for users in CITY X with the following profile:*
>
> - *Young professional in a rising business*
> - *Married, 25-30 years old*
> - *One child*

There were 10 teams, and each pair of teams was assigned a different city: Tokyo, Boston, Lisbon, Sydney and Cambridge. Figure 3 shows the scale prototypes of the solutions of the several teams.

Fig. 3. The prototypes that came out of the overseas experience for year 1

The third was the Entrepreneurship Accelerator, at the end of term 2. This accelerator caters for those who want to start their own companies or just want to know more about entrepreneurship. It is done in three days and again the students work in teams to develop a pitch for a new product/service/system of their own choice, within a theme. The instructor team will take the teams through the several steps of a good entrepreneurship practice, from idea to pitch to the investors, and touch on several topics like Singapore law and incentives on starting your own company, etc.

6 What the students are saying

The Innovation by Deign course in term 1 and Design Science in term 2 got an overwhelming positive reaction from the students, and some student provided suggestions to improve the course. The survey questions an respective answers can be seen in Tables 1 and 2. The answers were given on a Likert scale from 1 (strongly disagree; poor) to 5 (strongly agree; very good) with 3 being neutral/average.

Table 1: Survey results for the term 1 course on Innovation by Design

Survey question	% positive answers
The course has stimulated my interest to learn more about the subject	81%
The course has improved my knowledge on the subject.	81%
The course is well organized and structured.	76%
The course work load is manageable	95%
The course involved me in active learning experiences.	96%
After going through all the classes and assessments, I will be able to do what is prescribed in the learning objectives.	91%
Overall, I would rate this course as:	81%

Table 2: Survey results for the term 2 course on Design Science

Survey question	% positive answers
The course has stimulated my interest to learn more about the subject	85%
The course has improved my knowledge on the subject.	95%
The course is well organized and structured.	73%
The course work load is manageable	52%
After going through all the classes and assessments, I will be able to do what is prescribed in the learning objectives.	84%
Overall, I would rate this course as:	84%

Suggestions for improvement were also sought and well noted. Some comments were on the lack of time devoted to classes (for the case of IbD) on more technical content, and the fact that there is only one class per week. Other comments are more related to the content of classes (examples, exercises, etc.) which the students feel are not directly related to their respective projects.

For the overseas experience and the Entrepreneurship Accelerator, the survey results can be seen in Tables 3 and 4, respectively.
The most obvious outcome for the overseas experience was the mixed feelings about the duration. Half of the student felt that it was perfect, whereas the other half felt that it should have taken longer, some of them suggesting up to two weeks. There was no significant difference across the two batches of students (from SUTD and from Jiangnan University) on this.

Table 3: Survey results for the overseas experience

Survey question	% positive answers
How would you rate the entire experience	86%
How would you rate the interaction between team mates during the entire week?	86%
How would you rate the delivery of the week long experience?	86%
Were the materials/facilities provided adequate?	55%
Was the duration of the experience adequate?	50%

Table 4: Survey results for the Entrepreneurship Accelerator

Survey question	% positive answers
The program content was relevant and practical	94%
The atmosphere and interaction with the other participants was good and contributed to the sessions	85%
You are more confident in your ability to start your own company after completing the program	79%
The program duration (3 days) was efficient and practical	84%
I would recommend this program to fellow students	79%

The overall sentiment on the entrepreneurship accelerator was that it was excellent and relevant to the learning, although not all the students are planning on starting their own companies. There were lots of new knowledge to pair up with the knowledge acquired in the compulsory courses, so this complements nicely what they had done thus far. Some students are still not confident in applying this accelerator to their own work, which may be a factor to improve in future years.

7 Conclusions and future work

The program is nearing completion of its first year. The overall results have surpassed expectation, in the sense that most of initiatives were new and their outcome, although hopefully positive, was in effect unknown at the start. There are multiple elements of the program that require improvement, and it is now time to look at those and plan for next year. At the time of writing, the program is expected to run again with a total of 30 students for September 2020 intake, but with an increase of self-paid and company sponsored students and a reduced number of foreign students, as compared the September 2019 intake, which the present paper describes.

The Covid19 situation is expected to have an impact, although this is still not assessable. One of the issues that will potentially require monitoring is the overseas experience. Travelling restrictions may require a rethinking of this important component of the program: this may be turned into a national experience with another local university, or a virtual overseas experience conducted online.
Some of the suggestions for improvement will be analyzed and improvements will be made. For the term 1 course (IbD) it was suggested to have more technical content and more time devoted to classes instead of external speakers and studio work: a possible improvement will be to shift all invited speakers from IbD to I-P-R, thus freeing up space for more classes and more technical content. I-P-R did not have formal weekly classes, so a one-hour slot will be scheduled every week for external speakers to come and impart their knowledge to our students. This will not significantly affect I-P-R, as this is a research-based course, with work done in the labs, and a one-hour slot every week taken out of the lab will not be a problem.

The program coordination is considering to start student exchanges with other overseas universities, with the aim of making this program even more international and vibrant. The first exchange program with a European university is expected to start in 2021, potentially leading to a joint Master program. Similar initiatives are being considered with other universities.

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