Chapter 31
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, but mostly in the form of 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 and thus to realize design as a strategic investment for both companies and countries. The particular focus of this paper is 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. The organization allows practitioners to participate part-time. 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 easily find jobs in a context that is craving for people with this formal education: a broad view of design and the ability to implement it.

31.1 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 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

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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] into the 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 Fig. 31.1) and a significant number of electives (dark blue in Fig. 31.1) 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 Fig. 31.1, see Sect. 31.5 for details).

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 five part-time. Of the 30, a total of 15 have on-the-job experience ranging from 1 to 15 years. 24 scholarships were given, and one student is being supported by his company. The students come from seven countries (Singapore, Sri Lanka, India, China, Tanzania, Colombia and Indonesia) and have backgrounds in, e.g., robotics, IoT, chemistry, materials, aging/health care, drones/UAV, food science, design, sports, mechanics,
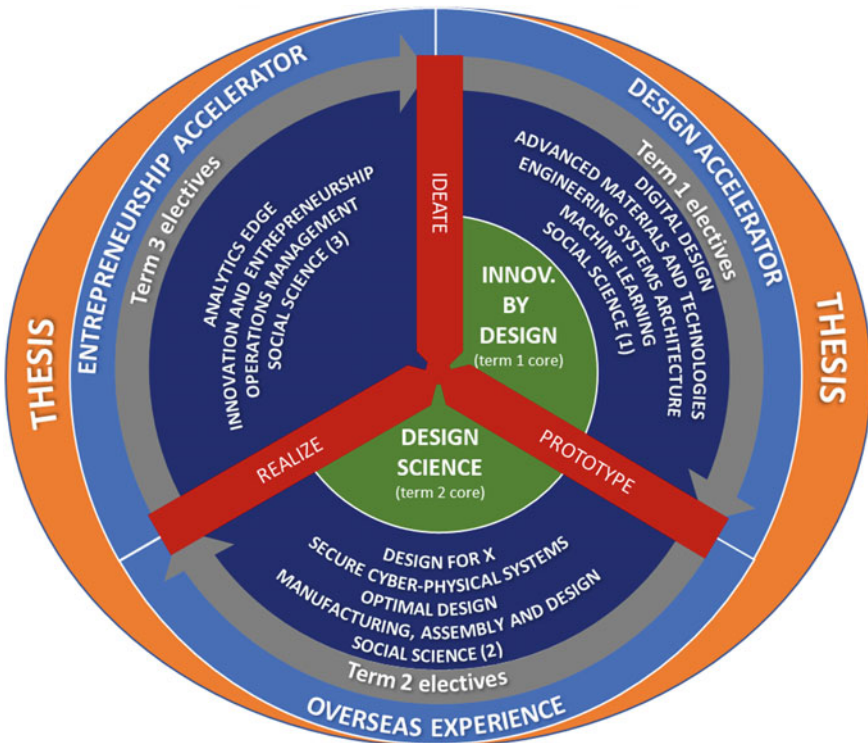

Fig. 31.1 Overall structure of the MEng in Innovation by Design

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 seven full-length projects, from discover to deliver. Those taking electives may have done even more. The sections below will describe various compulsory courses and experiences, student feedback on multiple aspects of the program and our plans for improvement.

31.2 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 4Ds (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.

31.3 The Compulsory Course on Design Science

The second term compulsory course is Design Science. This course aims at making the participants better qualified and equipped for research in Design Science, i.e., research that is focused on obtaining a better understanding of design and innovation, or on developing novel technologies, products, services or systems. The course provides insight into the existing design theories and models; understanding of the DRM design research methodology [7] to support planning and execution of research; an overview of Design Science methods; and the application of these methods to the participant's own research topic in the form of assignment. The course offers an active, project-based learning environment involving lectures, discussions, exercises, presentations, assignments and homework.

31.4 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 with 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 their chosen faculty advisor(s) expertise and embed the student in one of the SUTD's research centers, potentially having him/her join an ongoing research project. In this way, the student will be part of a team that is already doing 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 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 for I-P-R is not possible. The focus for each term is the following, but can vary depending on the topic:

- **Term 1: Ideate**: is discovering the topic and proposing potentially innovative ideas, through literature reviews, benchmarking, ideation techniques, etc.;
- **Term 2: Prototype**: develop prototypes (or experiments) that embody the ideas or gaps found in the literature;
- **Term 3: Realize**: conclude the study with a proof-of-concept of the ideas developed and prototyped earlier.

So far, students are hosted in four SUTD research centers showing the diversity of students and topic: SUTD-MIT International Design Center, iTrust Center for Research in Cyber Security, Digital Manufacturing and Design Center and Lee Kuan Yew Center for Innovative Cities. Some topics of the research projects which students have developed can be seen in Fig. 31.2.

31.5 The Experiences and Accelerators

As seen in Fig. 31.1, the program contains two accelerators and one overseas experience.

The first one is the 2–3 days Design Accelerator, specifically designed as a pre-term learning journey for those which may not be very familiar with design language and processes. 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, as well as the 4D design model (discover, define, develop, deliver).

The second is the overseas experience. This experience takes place between terms 1 and 2, after the students have gone through the first term Innovation by Design course. Students travel to another country to experience co-design (again within a theme that varies for each year) with 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
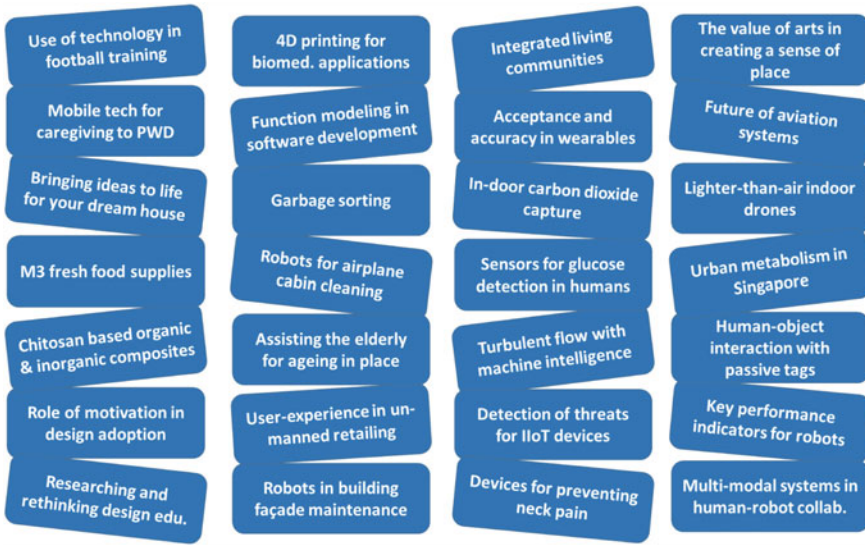
Fig. 31.2 Research areas of the first year students

Design at Jiangnan University, Wuxi, China, for one week and were paired with local students to solve a given problem. By the end of the week, all teams had to present a prototype of their solution. 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 growing business;*
> - *Married, 25–30 years old;*
> - *One child.*

The assignment came in five variants of CITY X: Tokyo, Boston, Lisbon, Sydney and Cambridge. With 10 teams, two teams were working independently on the same city. Figure 31.3 shows some of the prototypes.

The third experience was the three-day 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. Students again work in teams to develop a pitch for a new product/service/system of their own choice, within a given theme. The instructor team will take the teams through the steps of a good entrepreneurship practice, from idea to investor pitch, and touch on a variety of topics such as Singapore law and incentives for starting a company, etc.

Fig. 31.3 Prototypes resulting from the overseas experience in 2020

31.6 What the Students Are Saying

The Innovation by Design course in term 1 and Design Science in term 2 received an overwhelmingly positive reaction from the students. Students also provided suggestions to improve the course. The survey questions and answers can be seen in Tables 31.1 and 31.2. The answers were given on a Likert scale from 1 (strongly disagree; poor) to 5 (strongly agree; very good) with 3 being neutral/average. The percentages in the tables refer to the positive answers, i.e., agree/good (4) and strongly agree/very good (5).

Suggestions for improvement were also sought and well noted. Some comments were on the lack of time in IbD devoted to classes on more technical content, and the fact that there is only one class per week. Other comments are more related to specific content of classes (examples, exercises, etc.) which the students feel are not directly related to their respective projects. The Design Science course was strongly affected by the sudden COVID-19 measures, for which the very interactive format was ill-prepared. Suggestions for improvement are mainly related to the workload.

Table 31.1 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 workload 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 31.2 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

For the overseas experience and the Entrepreneurship Accelerator, the survey results can be seen in Tables 31.3 and 31.4, respectively.

The most obvious outcome for the overseas experience was the mixed feelings about the duration. Half of the students felt that it was very good, 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.

The overall sentiment on the entrepreneurship accelerator was that it was very good and relevant, although not all the students are planning on starting their own companies. They felt that the knowledge they acquired in this course nicely complemented the knowledge acquired in the compulsory courses. Some students expressed

Table 31.3 Survey results for the overseas experience (SUTD and Jiangnan University students)

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 31.4 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 were 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

that they are still not confident in applying the entrepreneurship knowledge to their own work, which is an issue we will look into in future years.

31.7   Conclusions and Future Work

The program's first year has just been completed. The number of applicants and the overall results have surpassed our expectation. The structure and content were new and very different from the existing programs, and it was not clear when we developed MIbD how varied the backgrounds of the students would be (see the research areas in Fig. 31.2).

There are multiple elements of the program that require improvement. At the time of writing, the 2020/21 program has just started with a total of 25 students, but with an increase of self-paid and company-sponsored students and a reduced number of foreign students, as compared to the September 2019 intake.

The continuing COVID-19 measures have an impact, but fortunately, in class teaching is allowed, albeit with a large number of constraints (masks, tracing, social distancing, etc.) that reduces the social elements of studying. We hope that early 2021 will see a return to normal. The January overseas experience is likely to remain affected. Traveling restrictions may still be in place. This requires a rethinking of this important component of the program. Alternatives are a national experience with another local university, or a virtual overseas experience conducted online.

Our own experiences in this first year and the students' suggestions have already resulted in some improvements; others require further analysis and preparation. 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 laboratories, and a one-hour slot every week taken out of the laboratory will not be a problem. The number of assignments in Design Science will be reviewed, and the taught content better adapted to the variety of research topics.

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

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