

# Capstone Global Design Collaboration: The NUS Experience

Stanley C.H Thian, Sha Ma, Jerry Y.H. Fuh, C. Quan, Y.F. Zhang and Li Lu  
*Department of Mechanical Engineering, National University of Singapore*

Many universities in Asia have started to incorporate the capstone design program into their engineering curriculums so that their undergraduates have the opportunity to apply what they have learnt into real-life design problems. However, many of these capstone projects were originated from companies within their own countries. With the trend of globalization, many engineering professionals must be able to work with their overseas counterparts in different countries and time zones. Thus, it is important to give our undergraduates a foretaste of working with overseas colleagues early. This paper describes the capstone program from the National University of Singapore (NUS) and shares the experiences and issues that were encountered during the collaboration with overseas universities.

*Corresponding Author: Stanley Thian, mpetchs@nus.edu.sg*

## ***Introduction***

The Department of Mechanical Engineering (ME) in the National University of Singapore launched its capstone program in Aug 2005. For the first time, the ME undergraduates were able to gain first-hand experience of the engineering design environment by working on real-life design projects. Students were exposed to the whole design process, including customer requirement collection, brain storming, concept generation, engineering analysis, design documentation, as well as prototyping and testing. Other than solving these technical problems, the students had to also deal with many non-technical issues such as team coordination, budget constraint, time management, scheduling, formal presentation and informal communication. In addition, professional ethics such as the use of Intellectual Property (IP) was also an important part of the training process.

Several Singapore government ministries such as Economic Development Board (EDB)<sup>1</sup> and International Enterprise (IE) Singapore<sup>2</sup>, have emphasized the paramount importance of design for the next stage of Singapore's economic development. Hence, a design council called *DesignSingapore Council*<sup>3</sup> was set up by the Ministry of Information, Communications and the Arts<sup>4</sup> in 2003. It is working closely with other government agencies, the design community, industry and education institutions to promote design in business and education, as well as to develop Singapore as one of the leading international centres for design creativity.

As a national initiative, *DesignSingapore Council* aims to place Singapore on the world map as a design

centre. It hopes to develop a thriving, multi-disciplinary design cluster of industries and activities in Singapore that has relevance and impact globally. The initiative also aims to bring design to business boardrooms, markets and new audiences. In 2009, DesignSingapore Council facilitated the signing of a Memorandum of Understanding (MOU) among eight of Singapore's design sector associations to form DesignS Alliance<sup>5</sup>.

As more and more companies are setting up design centres in Singapore<sup>6</sup>, tertiary institutions in Singapore play an important role in design education and training to support the design-focused industry. A local newspaper article reported that the international advisory panel to the DesignSingapore Council encouraged design learning to be included in all levels of school curricula, starting from pre-school, and not just at the tertiary level<sup>7</sup>.

## ***Approach Taken by Other Universities***

The students participating in the capstone program usually come from the same university. Each group is either made up of students from their own faculty or from different faculties to form a multi-disciplinary team. As globalization becomes an essential, the trend to collaborate / partner with overseas universities also follows. Hence, universities around the world are seeking to collaborate with other universities

## ***Overview of NUS Capstone Program***

The NUS ME capstone program is a two-semester course (module code ME3101 and ME3102) and typically consists of ME students only. In the USA, capstone projects are done by senior students, but in

NUS ME, it is mainly made up of third-year students with some ME4 students after their overseas exchange program due to the curriculum structure. However, there has been a trend in recent years where more senior-year students are either forming a group of their own or mix with other third-year students to take up a capstone project. The number of students in a group is dependent on the nature of the project and constraints given by the company. Typically, each group is made up of four to a maximum of six students.

Each team is supervised jointly by both a faculty staff and an industrial mentor throughout the entire program. In the first year of its capstone program, there were 28 projects from 12 companies and organizations, varying from consumer products, defense, electronics, contract manufacturing, automotive to maritime industry. To date, the total number of company sponsors has reached 134, offering a total of 255 projects.

### ***Integration with Other Faculties and Overseas Universities***

In the world of real life design, no single skill set of people can complete the job. It is very common to work with other professionals, such as Industrial Design (ID) people and even overseas colleagues. As such, it is necessary to expose and train our undergraduates in such environments, thereby giving them a head start before they graduate.

Since 2007, students from the NUS Industrial Design (ID) major have joined with ME students to work on several projects from consumer product companies. As these students are from the School of Design and Environment (SDE), it considerably enriched the learning experience of ME students. The ID students not only have an aesthetic perspective to the design, but also bring the unique perspective of industrial design to the ME students.

To stimulate working with overseas colleagues or collaborators, NUS ME started its global capstone collaboration with Peking University (PKU) in 2009, where NUS and PKU students (Fig. 1) worked together to develop a solution to a design problem. NUS ME also started another capstone collaboration with Brigham Young University (BYU) as well as with Penn State University (PSU) in 2010. In 2011, a tri-party collaboration involving NUS, BYU and PSU (Fig. 2) was started.



**Figure 1:** NUS students visit PKU



**Figure 2:** The tri-party global capstone design team

Such a global design concept has benefitted students coming from different countries (Singapore, China and USA). Each university student can learn and appreciate different design thinking and problem-solving approaches. Such a global collaboration was a very beneficial one in terms of teaching and learning of design. However, many challenges were also encountered.

### ***Challenges Encountered When Collaborating With Overseas Universities***

There were many challenges encountered when collaborating with overseas universities, including:

1. Selling the idea to companies
2. Different sponsorship amounts received
3. Time zone differences
4. Difference in academic calendars
5. Effective communication mode
6. Difference in the university syllabus
7. Division of tasks among universities

### **Selling the Idea to Companies**

Many existing companies are not keen to sponsor capstone projects that involve an overseas university. One of the main concerns is the issue of IP. The complexity / difficulty of managing such projects also

increase since it now involves foreign staff and students from a different country.

The ideal company is a company that has offices in both countries, and the office in each country is willing to provide supports. However, few companies have such close communication within their global network. Furthermore, the scope of the project has to be a good match for both universities' capability and duration. Hence, recruiting a suitable project alone is a difficult task.

### **Different Sponsorship Amount Received**

Each university charges different sponsorship fees for their capstone program. For example, BYU charges US\$20,000, while NUS charges S\$4,000. This problem can be solved if the sponsoring company is willing to pay both universities equally. However, not many companies are willing to do that since it incurs a high cost.

### **Time Zone Difference**

NUS ME has collaborations with two USA universities, i.e. PSU and BYU. The collaboration between NUS and BYU / PSU has a time difference of 12 to 14 hours. This time difference is challenging to both NUS and the US students. To find a common time slot for both parties, one of the parties has to be up in the morning (as early as 7am) or late in the evening (as late as 11pm) so that they can communicate via an Internet meeting using Skype or Adobe Connect. Hence, only committed students from participating universities should be assigned to these global design projects in order not to affect the outcome of the project.

### **Difference in Academic Calendar**

The duration of the PSU capstone is one-semester, while NUS / BYU / PKU capstone experiences are two-semester. In addition, there is about one month difference in the commencement date between NUS and PSU / BYU / PKU. As a result, the deadline for each university is also different. This is a critical issue because students are not in the same stage throughout the capstone program. Among the four universities, NUS has the earliest commencement date and thus also has the earliest closing date for the students. This issue can be resolved if the partnering university selects their students to work and communicate with NUS students weeks ahead of the actual start of their semester.

### **Effective Communication Mode**

Many good ideas often evolve from brain storming sessions. Hence, it is vital that students from each university are able to conduct brain storming sessions as if they were in the same room, despite being in different

continents and time zones. Therefore, the software selected must allow the students to be able to share their computer screens and make changes to their engineering drawing in real time. The microphone and speaker should have a noise cancellation functions so that the communication is clear. It is also be good to have a high resolution camera so that students can see the faces of each other clearly, since communication also involves non-verbal aspects such as facial expression. Most of the NUS students are using MSN, Skype, Adobe Connect and QQ (with China) to have Internet meetings, using either voice or video communication modes (Fig. 3). With the advance of Internet speed, there is not much concern in terms of speed. Due to a joint presentation in the interim and final, the function of sharing Power Point files on-line during the meetings and presentations may be needed. Figure 3 below shows one of the internet meetings.



**Figure 3:** One of the internet meetings with US students

### **Difference in the University Syllabus**

Singapore uses the metric system (also known as International System of Units (SI)) while USA uses the English system (also known as British Imperial) for their teaching. Therefore, NUS students are not well versed with the imperial system, while US students may not be used to the metric system. Therefore, students participating in this joint capstone program will have to re-learn their familiarity of the English or metric system. The origin of the project will determine which system is to be used. If the project is from Singapore, then students from both universities will have to use the SI system and vice versa.

### **Division of Tasks Among Universities**

Prototyping may be required in some capstone projects. When two or more universities are involved in a capstone project, it can get quite complicated when the need to build prototype surfaces. It is not easy since the final design will not be known at the early stage. Thus,

this aspect has to be taken into consideration when selecting a suitable scope for a project. The strength / capability of students from each university must be taken into consideration during the stage of selecting a suitable project for a global capstone project.

### ***Feedback from NUS Students***

After the completion of the first collaboration with PSU students in 2010, three questions were asked of the NUS students to gather some insights.

Below are some actual statements given by the NUS students to the three questions:

#### **(1) What have you learnt from this collaboration?**

*Student 1:* “This collaboration was not only useful in giving us a first hand experience of how things are done in both universities but also exposed us to a variety of challenges and benefits from such an international collaboration.

The project itself was an industrial problem and it gave us a real life situation where we had to deal with limitations regarding cost, manufacturing etc which made the project even more meaningful.”

*Student 2:* “I think this collaboration was a great learning curve in terms of working with people from various nationalities and across different cultures. The knowledge sharing between the students of the two universities helped us learn a lot about how the mindsets of work is in the US, and how we can work together to achieve a common goal.”

#### **(2) What was the most challenging part?**

*Student 1:* “The time difference made it difficult to collaborate to our full potential. We only had a couple of hours each day for a meeting. Also just the web cam was a very poor way of communication. Especially when it came to sharing drawings, etc.”

*Student 2:* “One of the most challenging parts was to feel like a team even though we had never met in reality. We met over virtual networks such as Skype and Adobe, however to get a feeling of togetherness was one of the most challenging, yet one of the most satisfying parts. Also, the time difference made it slightly difficult to arrange meetings at common convenient times, but everything worked out very well in the end.”

#### **(3) What was the most satisfying aspect from this collaboration?**

*Student 1:* “Learning about the different facets of the industry along with the opportunity to benefit from the resources of two universities were the most satisfying attributes about the collaboration!”

*Student 2:* “The most satisfying thing in this collaboration was that despite being so far away we were able to communicate very effectively and do the jobs assigned to each one of us in an efficient manner.”

### ***Conclusion***

When the NUS capstone program was first launched in 2005, only ME students were working together to tackle their capstone projects. But in a real-life working environment, it is unlikely for a group of pure ME people to work together. There will always be a need for people from a different skill set to be involved in the team. Hence, since 2007, ME students have involve ID students to work together if the nature of the project requires them. But having a multi-disciplinary team is no longer sufficient.

With the trend of globalization, students also need to learn to interact and work with overseas students remotely and effectively. Therefore, since 2009, NUS ME has started its global capstone projects with PKU, BYU and PSU. This collaboration gives participating students from the three universities the opportunities to learn how to interact and work with future overseas colleagues from places such as China and USA, thereby, allowing them to have a foretaste of the real-life collaboration experience on design before they graduate. The culture difference on design concepts also becomes evident when a joint design arrives. It is found that students were very much appreciated and benefitted from the global design concept and scenario they may face in future despite some extra workload and communication deficiency sometimes.

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