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Multicultural design education

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Abstract. In this paper, 55 students from three universities converged in Singapore for a 17-day Product Design module. They were given a design assignment that challenges them to extract the customer requirements, convert that to product specifications and to prototype the design ideas for testing. 9 teams comprising a mix of student from the three universities rose to the task. In this paper, some of the results will be described and the key lessons learnt will be shared.

1. Introduction

Globalization is common in today's world. Many products are designed in one country while mass manufacturing is done in another country. As a result, designers and engineers from different countries need to communicate with each other. In this paper, a multicultural design education is described, where the authors tried to mimic this kind of globalization environment for their students, so that they can be better prepared for their future engineering careers.

Three universities – two American Universities and the National University of Singapore (NUS) combined and ran an intensive hands-on design module over 17 days in NUS campus, where each team must have at least one student from each university so that they can experience multicultural environment; experience the different training / culture background of each member. Each team is made up of five or six students. The 55 participating students come from over ten different nationality such as Taiwan, Mexico, USA, Singapore, Malaysia, India, Vietnam, China among others. As a team, they need to collectively design and implement practical solutions to a local design challenge, through the design process taught in the class.

The design process was communicated step by step thru daily lectures, hands-on activities, company visit, as well as used as the platform for the design teams to get to know one another enough to work together well. Professors from each university take turns to lecture on topics related to design and prototyping. The teams were taught to select an area that they would like to tackle, writing a problem/solution statement, identify the customer needs, generating ideas, evaluation and selection, detail design and testing, whilst prototyping throughout the process, under the close supervision of the professors. Each group needs to do a presentation on the last day of their course, followed by a group report. Figure 1 below shows the typical day activity of this summer design module. The paper will describe some of the interesting results.

Typical Activities in Week 1	
Time	**Activity**
0900	Lecture on Specific Topic OR Team present their findings from their hands-on activities
1000	Lecture on Specific Topic
1100	Lecture on Specific Topic
1300	Hands On activities to practice topics taught
1400	Teams to report their findings
1500	Hands-On activities to practice topics taught
1600	Hands-On activities to practice topics taught
1700	Hands-On activities to practice topics taught

Typical Activities in Week 2	
Time	**Activity**
0900	Team to get feedback on their ideas / concepts / prototypes from Professors
1000	Lecture on Specific Topic
1100	Lecture on Specific Topic
1300	Group's project activity / Prototyping Time
1400	Group's project activity / Prototyping Time
1500	Group's project activity / Prototyping Time
1600	Company Visit
1700	Company Visit

Figure 1. Programme Schedule for the 17 day module.

2. Solution Statement

All the nine teams were tasked with the design challenge of cleaning of public areas in a sustainable way. All the teams went out to make observations after being taught the importance of observation in lecture. From one of the team observations, they noted that there is overflowing trash cans in public spaces is a common problem, especially in hawker centres. Hence, they decided to tackle the challenge of overflowing trash cans as it can lead to people littering or stacking their trash above the trash, thereby affecting the cleanliness. Hence, their solution statement is then to eliminate overflowing trash in hawker centre trash cans.

Another team observed the issue arises from burning incense paper and decided to work on the design of the bins. The team discovered that there are peak periods throughout the lunar calendar year, "such as Qingming Festival and the seventh lunar month" [1]. According to the Singapore Straits Times newspaper [2], scientists from Nanyang Technological University (NTU) found out that the concentration of pollutant particles, such as PM2.5, increases tremendously during such seasons. This is due to the massive amount of incense paper burning during the festival [3]. Fly ash and soot in smoke can also dirty and stain public areas. Incense paper burners are ubiquitous in densely populated housing estates. Hence, the team's solution statement was to develop a product that will reduce the undesirable and harmful emission products of incense paper combustion in housing estates.

Yet another team went to a beach to make observations and notice that trash washes up from the ocean onto the coastline and beach users may intentionally or carelessly leave their rubbish on the sand during their stay. Unless there is someone to go pick up the trash, it will linger to cause a potential health hazard to beach users and wildlife while diminishing the overall appearance of the beach. Hence, the team solution statement was: Develop an efficient device to aggregate and remove the accumulated trash larger than 16mm by 16mm on the dry sand of the beach.

3. Customer Needs

Each team needs to identify their main stakeholders and customers correctly.

In the case of the team tacking the overflowing bins, they have identified the main stakeholders are the general public and the cleaners. They conducted an online survey was conducted with members of the public and it was found that two-thirds of respondents have encountered the problem of

overflowing trash cans. Some issues voiced were how overflowing trash cans made hawker centres feel dirty, and the difficulty faced in disposing of trash in overflowing trash cans. All respondents felt that keeping hawker centres clean and litter-free is of great importance, and ease of use of trash cans was also generally valued. From their interviews with cleaners, they found that trash is collected more than once a day, and at times, trash cans are filled up quickly. The cleaners expressed satisfaction with the size and ease of use of existing trash cans due to its simplicity.

The input from cleaners and survey respondents enabled the students to identify the needs and relevant metrics outlined in Table 1. The team found out that their design should first and foremost prevent trash overflow and contribute to cleanliness of hawker centres at the same time. It should allow for easy removal of trash and reduce the number of times of trash collection for more efficient and sustainable cleaning. Their design should minimize odour and appear clean and usable so that the general public has a better usage experience. It should also be weatherproof and affordable so as to compete with trash cans as a viable alternative.

Table 1. Customer Needs and Evaluation Metrics

	Metric	Adjusted Total Volume (ATV) Ratio	Corrosion rate	Flexural/Tensile Strength	Trash removal procedure	Aesthetically Pleasing	Cleanliness	Usability	Cost
	Need								
#1	Keep trash from overflowing out of the can	X				X			
#2	Be weatherproof		X	X					
#3	Minimize odor						X	X	
#4	Allow for easy removal of trash				X				
#5	Appear clean and usable					X	X	X	
#6	Reduce number of times trash needs to be collected	X							
#7	Be affordable								X

For the team tackling incense burning, they have identified that their customer are the residents who employ the communal burners to burn their incense paper where their needs are expected to revolve around the incense paper burning process. Another ‘customer’ is the government, because these communal incense burners are under the jurisdiction of the respective Town Councils. Their needs are expected to revolve around maintenance and production costs. From the team’s interviews and benchmarking competition, they found out that the main customer needs are - cheap, efficient burning of incense paper (fast, complete, and uninterrupted experience), multiple users, and lastly, reduced spread of soot and ash.

As for the team tackling the beach cleanliness, they identified two main categories of customers; Volunteers / workers and government / cleaning contractors. Each category comes with a specific set of needs that they identified when they conceptualizing the design for the product.

4. Products Specifications and Benchmarking

Using the overflowing bin as an example, Table 2 below outlines the product’s target specifications for each of the metrics identified. The acceptable value range sets the minimum performance the team’s product should achieve, whereas the ideal value shows the performance level they ideally want their product to attain. The numbers in the “Corresponding Needs” column correspond to the numbered customer needs in Table 1.

To aid in specifications and design, existing trash compactors and bins were rated on metrics similar to those presented in Table 2. The benchmarking results are presented in Table 3 below.

Table 2. Products Specifications

Metric	Units	Corresponding Needs	Acceptable Value Range	Ideal Value(s)
Adjusted Total Volume Factor	unitless	#1, #6	>=1.5	>=3
Corrosion rate	mm/year	#2	negligible	~0
Flexural/Tensile Strength	MPa	#2	~31.7	>=31.7
Trash removal procedure	no. of steps	#4	<=6	<6
Aesthetically Pleasing	Subj. 1-5 Scale	#1, #5	>=3	~5
Cleanliness	Subj. 1-5 Scale	#3, #5	>4	~5
Usability	Subj. 1-5 Scale	#3, #5	>=4	~5
Cost of product	SGD	#7	<$175	<=$140

Table 3. Benchmarking of a Competitor Products

		SmartPack Model SP20 - Automatic Compacting Receptacle	Household Essentials Trash Krusher Manual Trash Compactor, 40L	Whirlpool Gold Trash Compactor	Otto Mona	Clean Cube
Metrics	**Units**					
Adjusted Total Volume Factor	unitless	8	2	4	1	5
Corrosion rate	mm/year	~0	~0	~0	~0	~0
Flexural/Tensile Strength (Durability)	MPa	31.7	505	505	31.7	>390
Trash removal procedure	No. of steps	7	9	8	6	9
Aesthetically Pleasing (1-5)	Subj. 1-5 Scale	4	4	5	3	4
Cleanliness (1-5)	Subj. 1-5 Scale	3	3	4	4	3
Usability (1-5)	Subj. 1-5 Scale	4	4	4	4	4
Cost of product	SGD	S$8019	S$195	S$997.65	S$175	S$2500
Motor Specs	hp	0.5	N/A	1/3	N/A	1/6

The team also listed details each of the metrics and the derivation of each of the specifications.

- Adjusted Total Volume Factor: This metric is the ratio of volume occupied by the trash before compaction to that after compaction. From talking to cleaners, the team found that in certain places trash is collected three times a day; therefore, to reduce the number of times of trash collection, it was necessary to set this factor to at least 1.5.
- Corrosion Rate: In Singapore, trash bins must be able to withstand rainy weather without corroding. The current trash bins in hawker centres are made of plastic and so do not corrode; therefore, to avoid creating a new problem, the team aim for negligible corrosion in our prototype as well.
- Flexural Strength: This metric details the strength of the material of the bin. The team established 31.7 MPa as the target for their prototype because the current bins, made from HDPE plastic, are durable and have this flexural strength.
- Trash Removal Procedure: This metric counts the number of steps a worker takes to remove trash from a certain receptacle (including opening the bin, tying the bag, transferring trash to truck, etc.). Based on the current number of steps, which workers expressed satisfaction with, the team set the target at 6 steps for our prototype.
- Aesthetically Pleasing, Cleanliness, and Usability: These data were derived from surveys based on a 1-5 scale, 1 being the lowest and 5 the highest.
- Cost: The current bins used in food centres cost approximately S$140; since the team's design includes a compactor as well, they determined that it was acceptable for the cost to be slightly higher

5. Prototyping

Prototyping is one of key skills to learn for design process. Each group were instructed to use cardboard (or any inexpensive materials) to create many mocks up for each of their concepts from their brain storming, so that they can learn and have a feel of the advantage / limitation of their concepts.

For the incense paper burner, several mocks up were created before the final life-size prototype was made of metal oil drums. The original concepts were retained apart from slight tweaks in accordance to the workshop's machining capabilities. One major change was made in the position of the holes on the 2 chimney layers (Figure 2), following the test observation of the behaviour of soot deposition. The roof of the burner also no longer has an outlet as in the first cardboard prototype.

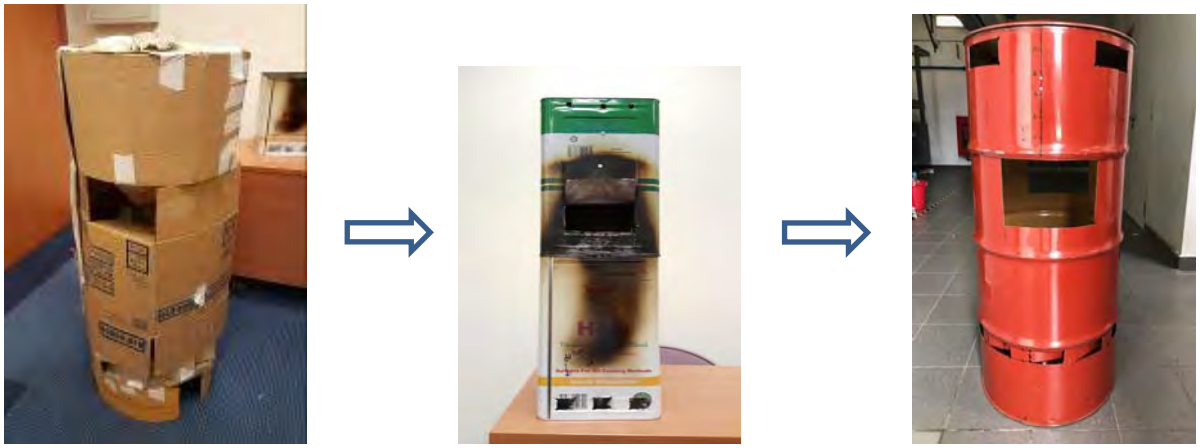


Figure 2. Various stages of prototyping; from mock up (left and center) to final prototype (right)

Testing was carried out based on two performance metrics as outlined in team report. First, time taken to complete burning of four stacks of incense paper (recommended number by shop owner). This indicates the extent of complete combustion the burner can produce. Second, visual inspection of the amount of smoke emitted. The amount of smoke is indicative of the extent of incomplete combustion. The less smoke produced throughout the entire process, the less products of incomplete combustion, such as soot and ashes, will be released as well. Near the late stages of burning, less smoke being produced as the flames start to die down also proves a more effective burner.

Similarly, for the beach cleaning project, the team also fabricated several mocks up (Figure 3) to determine the function of each concept before finalising the final prototype.

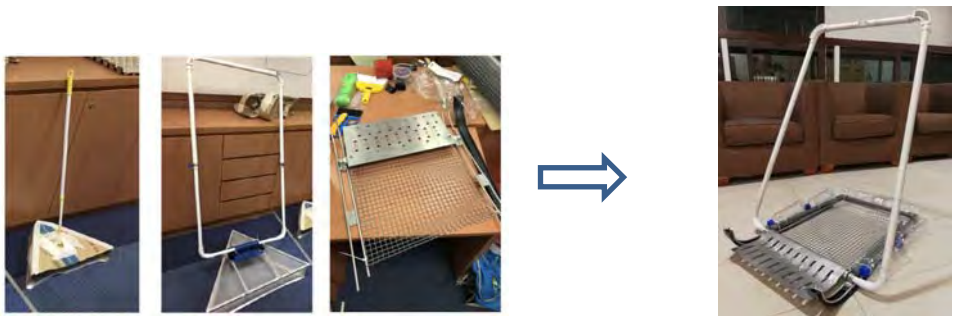
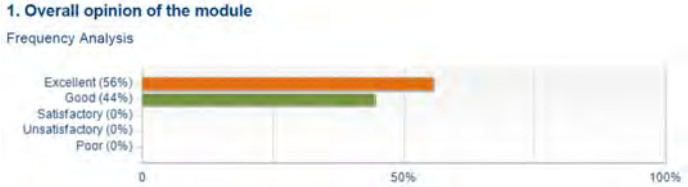


Figure 3. Various stages of concept mock up (left) to final prototype (right)

6. Feedback

A feedback session was conducted on the last day and figures below show the data obtained. Most of the students have excellent opinion of this 17 days intensive module and enjoyed the interactive activities throughout the modules.



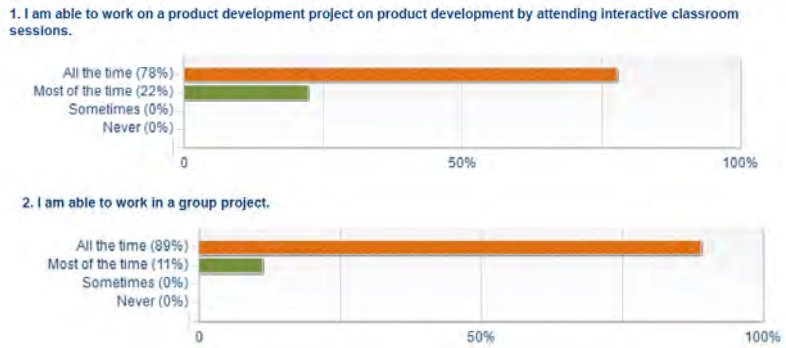


Figure 4. Charts obtained from feedback sessions

6.1 Quotes from students

Below are four quotes from different teams during the feedback sessions.

"Our team had its differences in ideas about the way of doing things while building the prototype, as well as what to make the prototype out of, but we ended up *working those differences* into our multiple prototypes to create several successful prototypes"

"For the most part, the team functioned well. There was *some disunity initially* in choosing the aspect of the decomposed problem that we would try to solve but it was resolved without much difficulty. One team member, made tasks slightly more difficult by becoming attached to one concept and disagreeing with the amount that the team focused on customer needs, but in general the team *listened to each other's suggestions and overcame disagreements politely*"

"When we met many unforeseen obstacles but we was able to work together without any disputes. We were able to *convey our ideas across* and substantiate it with why it would be the best idea if there was an opposing one, always coming to an agreement thereafter"

"During the team function during the building of the prototype, there were a lot of barriers both cultural and age/class related. Sometimes the barriers got the best of us and created some complications. But for the most part we were able to break through those barriers and get things figured out. But in the end I think we were able to come out with a few prototypes for which everybody put effort in throughout the entire process"

7. Conclusion

From the feedbacks received, the learning experiences were tremendous and the students' feedbacks were highly positive. One of the common benefits given in the feedback was that they have learned to appreciate from each other's thinking due to their different culture / training throughout the design process. Students find this intensive and interactive module enjoyable and beneficial. As each team have members from at least three different nationalities and from three different Universities, they were able to overcome culture difference challenges and learned that their culture difference can be an asset towards designing a good product. Through the well-defined design process, lectures and hands-on activities, as well as the close interaction with the professors to get feedback on their concepts throughout the 17 days module, they were able to successfully prototyped their proposed designs with reasonable quality.

Acknowledgements

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