Systems Approach to Designing a Dynamic Kitchen for University Residencies to Improve Students' Campus Life Experience

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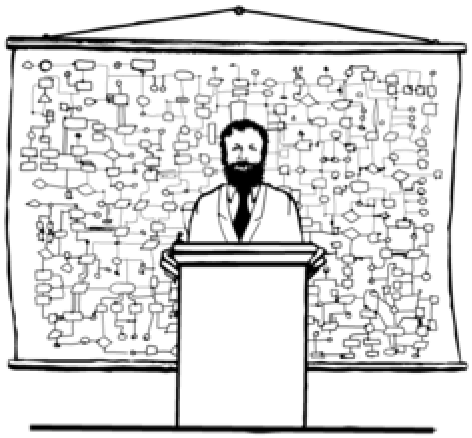

"Now that you have an overview of the system, we're ready for a little more detail"

Image retrieved from http://upload.wikimedia.org/wikipedia/en/thumb/6/6e/ArchitectureCartoon.png/300px-ArchitectureCartoon.png

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1.0 Abstract

This report details the systems approach taken to design a new kitchen for Fenner Hall to satisfy the student clients' requirements as well as providing a stimulating and engaging environment to improve student campus living experience. The system tools were utilised to decompose the kitchen system to gain insights for direction of research which ultimately led to an original and innovative design that is successful at the initial level of testing.

2.0 Introduction

The kitchen is a major factor in the wellbeing and overall experience of campus life for university students living in residencies. Apart from food being a necessity that has direct impacts on study through health, cooking in communal environments are a commonplace for social interaction (Clear A, 2013). Currently at ANU, the kitchens at Fenner hall are relatively old, last refurbished in 1992 and there is profound student dissatisfaction evident from client interviews. This system approach aims to design a dynamic kitchen that is both functional and facilitative of student engagement for Fenner Hall to improve the overall student living experience. The client for which this design is focused for are the students living at Fenner Hall.

3.0 Problem Overview

There are currently 11 full and 3 half sized kitchen bays accommodating over 500 students at Fenner Hall. Each bay includes 4 sets of stove tops, 4 sinks, 2 ovens and 2 microwaves with the total kitchen area around $741m^2$(see appendix A). Fridges and cupboards are arranged around the edges of the bays, forming a wall between the bays, leaving the centre space as the dining area (see appendix B). Faulty, old equipment, dirty environment, insufficient and insecure fridge spaces are some of the major reasons for student dissatisfaction with the kitchens. This attitude along with the blocked in layout, discourages student engagement and is detrimental to the campus living experience.

4.0 Requirements Analysis

Through interviews with various students living at Fenner Hall, the interactions between the client, and the kitchen was understood along with the major concerns residents had with the current system. Customer requirements obtained from the interviews are shown below in order of importance with some relevant insight gained through further questioning (Dym, 2009) and observation.

1. Reliable Equipment: Many of the stoves and ovens are faulty due to their long use, which is a major source of annoyance.

2. Clean: Spills and stains are neglected by students due to a lack of respect from dissatisfaction. The filth furthers this attitude, worsening the condition.
3. Cool Design: The current environment is dull and demotivating.
4. Large Storage Space: Insufficient storage space especially for fridge and freezer.
5. Secure: The lack of security for the fridges leads to incidents of theft.
6. Well ventilated: Odours linger due to the blocked off design and insufficient ventilation
7. Dining Space: The students appreciate the dining space and would like it to be a feature in a new design.

Since most of the customer requirements obtained are based off the student's opinion on the existing system, the preference here is actually more of a reflection of the inadequacies of the current kitchen. Therefore, certain requirements may have been missed from client interviews which can be added in after consideration of the design aims. 'Open Plan Design' was not an initial requirement but added in order to better incorporate the socialising aspect of the system to improve student experience in response to the general 'blocked off' feeling from students. 'Safety' is another requirement that was not a concern from clients but must be included to ensure the design fulfils regulatory standards.

Customer Requirement	Reliable Equipment	Clean	Cool Design	Large Storage Space	Secure	Well Ventilated	Dining Space	Open Plan Design	Safety	Total	Rank
Reliable Equipment		1	1	1	1	1	1	1	0	7	2
Clean	0		1	1	1	1	1	1	0	6	3
Cool Design	0	0		1	1	1	1	1	0	5	4
Large Storage Space	0	0	0		1	1	1	0.5	0	3.5	5
Secure	0	0	0	0		1	1	1	0	3	6=
Well Ventilated	0	0	0	0	0		1	0	0	1	7
Dining Space	0	0	0	0	0	0		0.5	0	0.5	8
Open Plan Design	0	0	0	0.5	1	1	0.5		0	3	6=
Safety	1	1	1	1	1	1	1	1		8	1

Table 1 Pairwise analysis

The ranking of the requirements was mainly based on the client preference with safety as a pass fail condition. Dining Space were considered least important since some students have decided to eat in their own rooms instead due to the unpleasant environment of the kitchen, the effectiveness of a dining space is heavily dependent on other requirements such as 'Clean', 'Cool Design', 'Well Ventilated' and 'Open Plan Design'.

In order to be able to optimise the design according to these requirements, translated design requirements along with performance metrics and inter-relationships between them are analysed.

These are presented in the following house of quality.

Legend	
+	Positive Relationship
-	Negative Relationship
+ (highlighted)	Max
- (highlighted)	Min
1	Weak Relationship
3	Average
9	Strong

(P) Performance Requirement
(F) Functional Requirement

	Lifetime	Cleanliness	Secure	Ventilation	Fridge Space	Freezer Space	Cupboard Space	Dining Space	Visible Space	Colourful
Lifetime (P)										
Cleanliness (P)										
Secure (P)										
Ventilation (F)		+								
Fridge Space (P)		+	-							
Freezer Space (P)		+	-		-					
Cupboard Space (P)		+	-			-				
Dining Space (P)		-					-			
Visible Space (P)		-	+	+	-	-	-	+		
Colourful (P)		-							+	

Customer Requirements	Rank	Lifetime	Cleanliness	Secure	Ventilation	Fridge Space	Freezer Space	Cupboard Space	Dining Space	Visible Space	Colourful
Direction		+	-	-	+	+	+	+	+	+	+
Performance Metric		Years	Units of Rubbish/m^2	Thefts/week	m^3/second	L	L	m^3/unit	m^2	m^2/bay	Number of Colours
Reliable Equipment	2	9			1	1	1				
Clean	3		9		1	3	3	3	3	1	1
Cool Design	4		1						3	3	9
Large Storage Space	5					9	9	9		3	
Secure	6			9		1	1	1		1	
Well Ventilated	8				9				1		1
Dining Space	7		3		1				9	3	
Open Plan Design	6		1	1					3	9	
Safety	1		3		3						

Table 2 House of Quality

Safety does not have a design requirement here as it will be ultimately decided by a pass/fail test of regulatory standards (Food Standards, 2001). Lifetime was used as the design requirement for measuring reliability of equipment mainly due to its general applicability to various kitchen appliances, which would otherwise require an analysis of multiple metrics specific to different equipment. Visible space is the perceptible area for the student in the kitchen bay. This was selected for 'Open Plan Design' mainly in response to the original client concern of feeling blocked off as it was decided that a less restricted field of view would be a remedy. The subjective nature of the requirement 'Cool Design' was difficult to translate. It was ultimately decided to use colour to achieve this as colour is both simplistic and effective to create a pleasant environment. Pale colours, especially blue (Ayash, 2015) can stimulate feelings of relaxation and create a sense of open space. Some colours, such as vivid red, have negative effects so the number of colours and types of colours used will be regulated in the design according to Ayash's research. Cost is an important factor but not included here as the client, students, are not as concerned as the administration.

A clear correlation can be seen between cleanliness with both storage and open space. More storage space decreases the likelihood of utensils or food being left around while larger open spaces (dining and visible) reduces the density of rubbish which is the metric used to determine cleanliness. However, there is the obvious trade-off between storage and open space since there is limited area for the kitchen. It can be argued that increasing open space has a greater effect on cleanliness since it directly lowers the cleanliness metric because most of the items left would be rubbish rather than utensils or useful food. Also, larger storage spaces may be more difficult to secure which can lead to more food thefts. Ventilation, which can have impact on the health of students (Lee, 2011), is also aided by larger open spaces which allow convection currents to flow freely (BRANZ, 2007). Carefully selected colours can also improve the perception of open spaces and cleanliness whilst also creating an engaging environment. Therefore, utilising colours, maximising open spaces in either the form of dining space and visible space will be a focus of the design since cleanliness is the second most important client requirement. Although equipment reliability is the most important concern, there is little adjustment that can be made apart from replacing the old equipment and improving the lifetime or efficiency of these appliances will be very complicated and beyond the technical scope of this course. The positive correlations with ventilation, colours and potential facilitation of student engagement in the kitchen are also appreciated as they can improve the campus living experience which is one of the aims of this design. Before we approach the designing of the system, we analyse the functions based off the interactions from the interviews with considerations to the design requirements.

5.0 Scoping and Functional Analysis

These interactions are represented through a use case diagram below.

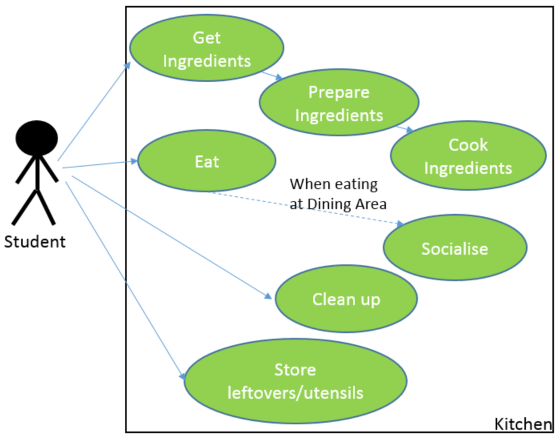

Figure 1 Use Case Diagram

The system boundary has been restricted to the kitchen with only the student's involvement considered. Although there are other factors such as Fenner Hall administration represented by cleaner staff, they are beyond the scope of this design. The endogenous, exogenous and outside factors will be formalised with the subsystem interface discussed later on. We detail these interactions through the following FFBD describing the desired functions the system will perform for the student to satisfy requirements and design aims.

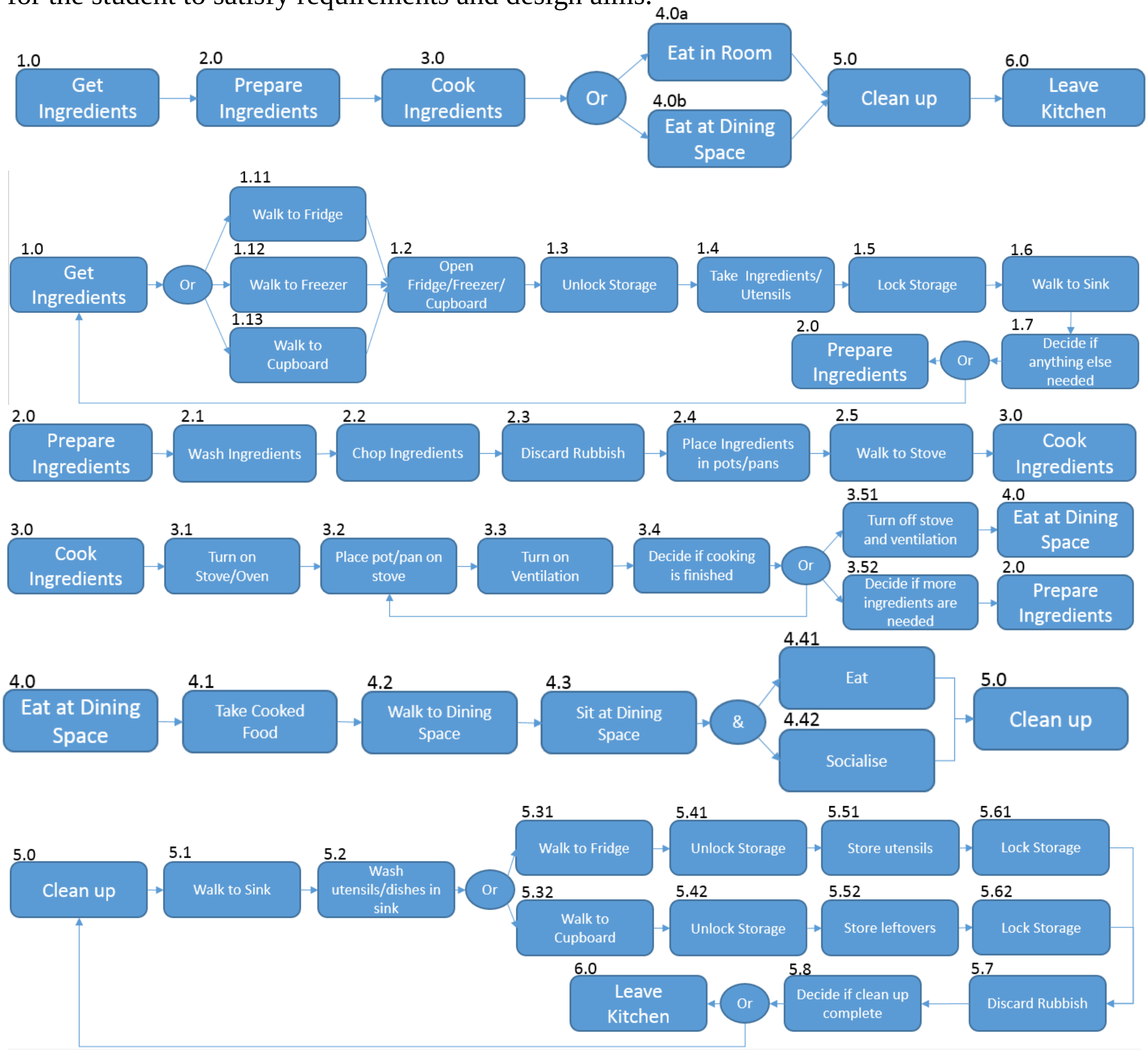

Figure 2 Functional Flow Block Diagram of Student Interactions

These functions are not an exhaustive description of the proceedings in the kitchen as one of the key functions, 4.42 Socialising can occur in other processes as well. However, since this FFBD aims to describe a typical interaction, socialising has been decided to mainly occur during eating since it is when the least amount of focus is required though it can also occur during cooking or cleaning. One common function here is related to walking as in all but 3.0, involves walking. Repeated trips are possible in 1.0 and 5.0 which suggests that proximity between the sink, storage areas and stove are desired to reduce inconvenience and possible safety hazards when carrying heavy items. This relates to the kitchen work triangle design guide where the combined distance between these 3 areas should be under 7.9m (Build, 2015). Another important insight here is the locking process tied with storage also in 5.0 and 1.0. Since security was one of the customer requirements, security measures are required for storage to prevent theft. A locking system that requires low effort may be desired as the student is often carrying things to and from the storage. There is also the likelihood that if the mechanism is too fussy, the student may be too inconvenienced to lock between trips, undermining the security entirely. Therefore a possible trade-off exists in the complexity of the lock, which may affect the degree of security, and student experience. From this functional analysis, insight into satisfying the safety and secure requirement has been gained which will be considered in concept generation. Following on from this, the design will be examined at a systems level to obtain further insight.

6.0 Subsystem Analysis

The subsystem interface of the design will highlight the relationships between subsystems to provide a higher level perspective.

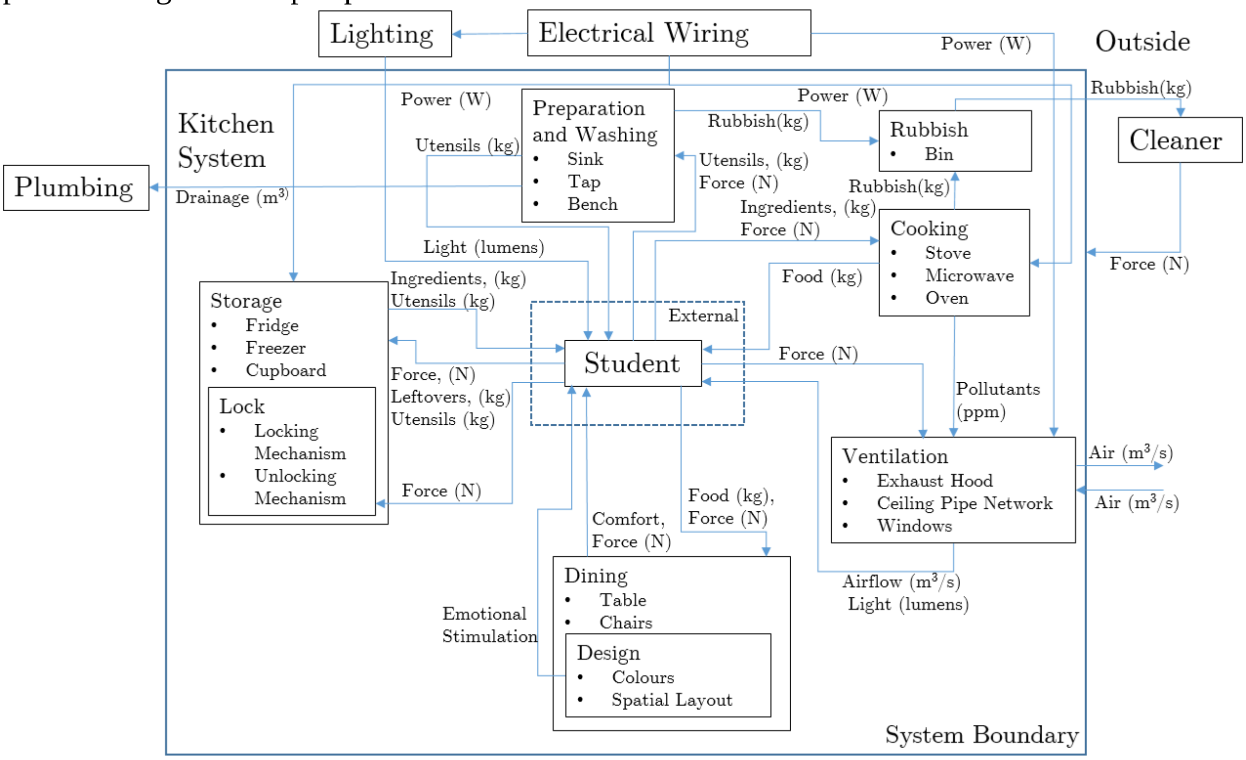

Figure 3 Subsystem Interface of Kitchen

The interface demonstrates that all subsystems involved revolve around the student which reasserts the design focus of the kitchen work triangle. Inputs and outputs between Storage, Cooking and the Preparation and Washing subsystem flow via the student so minimising the distance between them is preferred. Lighting was initially excluded from the system boundary but one of the insights gained was the opportunity to integrate indirect lighting with the exhaust hood component in the ventilation subsystem. Further research also discovered that indirect lighting can stimulate pleasant and cool feelings (Shin, 2015) which would work well with the desired aims of using colours to create a relaxed environment. Considerations were made with utilising natural light through windows which will be incorporated, however, through the interviews it was noted that most of the cooking occurs at night which is unsurprising considering the university timetables. The Design subsystem was integrated with the Dining subsystem as most of the social interactions are likely to occur during eating so the focus of creating a pleasant environment will be in the dining area. However, the same colour ideas will also be applied in other areas where possible. The Lock subsystem is naturally integrated with storage and also a modularised mechanism will be chosen for the three components of storage. This is to simplify the potentially tedious process and also maintenance for administration which although is not included in the system scope, can improve the reliability of the system as broken components can be quickly replaced. This may incur higher security risks as breaches can be universal across all storages so a trade-off exists between reliability and security. With the subsystems layout, the following attributes cascade will provide direction towards which subsystems to improve according to design requirements and aims.

7.0 Attributes Cascade

Attributes are often intangible characteristics that are determined by both customer and design requirements (Smith, 2008). 6 primary attributes were developed through consideration of the requirements and aims for the design. The following cascade expands them and relates relevant subsystems.

Primary Attribute	Secondary Attribute	Tertiary Attribute	Subsystems
Reliability	Lifetime	Appliance Lifetime	Cooking, Storage
	Maintenance	Appliance Downtime	Cooking, Storage, Lock
Cleanliness	Environment	Air Quality	Ventilation
		Rubbish and Stain Density	Dining, Rubbish, Preparation and Washing
Attractiveness	Environment	Colours	Design
		Lighting	Ventilation
		Layout	Design
Spaciousness	Dining Space	Table	Dining
	Perceptive Space	Colours	Design
		Open Plan Layout	Design
Storage Space	Equipment Storage	Cupboard Space	Storage
	Food Storage	Fridge Space	Storage
		Freezer Space	Storage
Security	Lock	Locking complexity	Lock
		Unlocking complexity	Lock

Table 3 Attributes Cascade

An initial examination concludes that storage and design are the subsystems with the most effect on satisfying requirements. However, because of the nature of the design, the subsystems of Storage and Cooking are heavily dependent on appliances which do not have much space for optimisation apart from selecting commercially available options. This is also because in order to optimise the hardware, the technical requirements are beyond the scope of the design. Therefore, the subsystem Design is the most significant one to focus when considering the solution. Also, design can readily integrate into other subsystems due to its general nature. Storage space can be maximised with more efficient designs and the arrangement of Ventilation and Preparation and Washing subsystems can also improve their functions. With these insights from both functional and systems level analysis, solutions will be explored by a concept generation with consideration to existing designs.

8.0 Testing and Concept Generation

In order to narrow down the potential concepts, the current kitchen system will be quantitatively tested where possible and qualitatively otherwise against the design requirements. Since the kitchen system is operational, Type 4 testing (Blanchard, 2010) is conducted.

Lifetime	Cleanliness	Secure	Ventilation	Fridge Space	Freezer Space	Cupboard Space	Dining Space	Visible Space	Colourful
20+ years	22 units of rubbish/m^2	Key Lock and Padlock	Insufficient	68L	21L	0.135m^3/unit	192m^2	23.8m^2/bay	Dull Grey, Wood Stain

Table 4 Testing of current system

The data is gathered from measurements and observations of the kitchen (see appendix C). Cupboard space does not take into the number of cupboards because each student only has one cupboard. Since Fenner has a max capacity at 500 students, at least 500 cupboards will be required but this is kept constant. Some data such as the ventilation rate, was not obtainable without complex measurements so the qualitative impact was recorded as the student did not feel it was enough. For Secure, the number of thefts are not recorded so the current components are used as the benchmark instead. For lifetime, this was difficult because the kitchen was last renovated in 1992 (see appendix D) so for the working appliances, their lifetime is very long but for the faulty, the years is unknown. Since the average lifetimes for appliances is generally below 20 years (MrAppliance, 2015) a total replacement will be required in the solution. These values will also be useful in the evaluation of the solution, though for the qualitative measures such as Ventilation, Type 3 testing (Blanchard, 2010) will be required to validate improvements. An important point to mention is that the fridges are shared between 5 people with one padlock for only the fridge section. This increased security risks as if only one member did not lock up, all members' items were unlocked. Also, the key lock system may not be convenient when carrying as one hand is required to hold the key and insert while the other holds the padlock in place. These are all qualitative standards that require subjective testing by students to compare.

From the testing results, certain requirements such as the lifetime, fridge and freezer space can be simply improved by new appliances with larger volumes. Cupboard, dining and visible space can be improved by designing a better layout which will also allow potentially larger appliances with more volume to fit. Colourful, Security and Ventilation have interesting concepts to explore. Designing the layout however, encompasses all these factors and will be the most important concept to explore, as indicated by the attributes review analysis previously. The concept generation process into the selected areas along with decisions are summarised below.

Colour

Lighter colours, in particular pale yellow and both vivid and pale blue, will be the emphasised colours since they stimulate focused and relaxed emotions (Ayash, 2015). The lighter tone can also improve lighting as the closer a colour is to white, the less light it absorbs (Gordon, 2015).

Security

The current use of key operated padlocks was completely rejected on the basis that it required too much effort from the students and interferes with carrying items. Digital keypad locks were considered and although they were the simplest to operate, the much higher cost was considered impractical and such electronics may be damaged in a wet kitchen environment, lowering reliability. The chosen concept was combination padlocks as only one hand is required to operate them in both unlocking and locking. A key is no longer required which also improves reliability as cases where the key is lost no longer inhibit the functions of the storage system. Regarding the issue with shared fridge spaces, transparent doors along with individual labelled compartments, much like the ones implemented in Burton and Garret Hall (see appendix E) will be used. This reduces risk as students are responsible for their own items and the transparent door can also act as a deterrent for theft as they can be seen accessing someone else's compartment.

Ventilation

Windows will be more incorporated in the design for increased ventilation (BRANZ, 2007) while also providing lighting during daytime and summer nights. However, they will not be overwhelming as in UNSW Colombo house's design (see appendix F) since the majority of the cooking is done at night, and during winter the windows need to be shut. Therefore, exhaust hoods were selected to provide the extra ventilation required as well as indirect lighting which will not only improve lighting but also stimulate calm feelings (Shin, 2015).

Layout

To increase the dining area and visible space per bay, alternatives to the current walls of cupboards were explored through open plan designs. This would involve reducing the cupboard walls down to 1.1 m in height to still provide sufficient storage capacity, bench area and also maximise visible area per bay. In order to compensate for the loss in height, a zigzag layout of cupboards were used to more efficiently utilise the limited width of the bay while providing some interest in the design. To satisfy the kitchen work triangle, which the current system has failed for certain stove locations, the sink and stove have been integrated with inspiration from the UNSW Colombo House design (see appendix F). Fridge and freezer locations have also been designed to be nearby stove locations to keep the max distance under 2.7m. Careful considerations have also been made to the dimensions of areas to satisfy the dimensions of existing commercial appliances providing larger storage spaces.

9.0 Design Communication

The selected generated concepts were combined and a following 1:1 scale Sketchup Model of the design created.

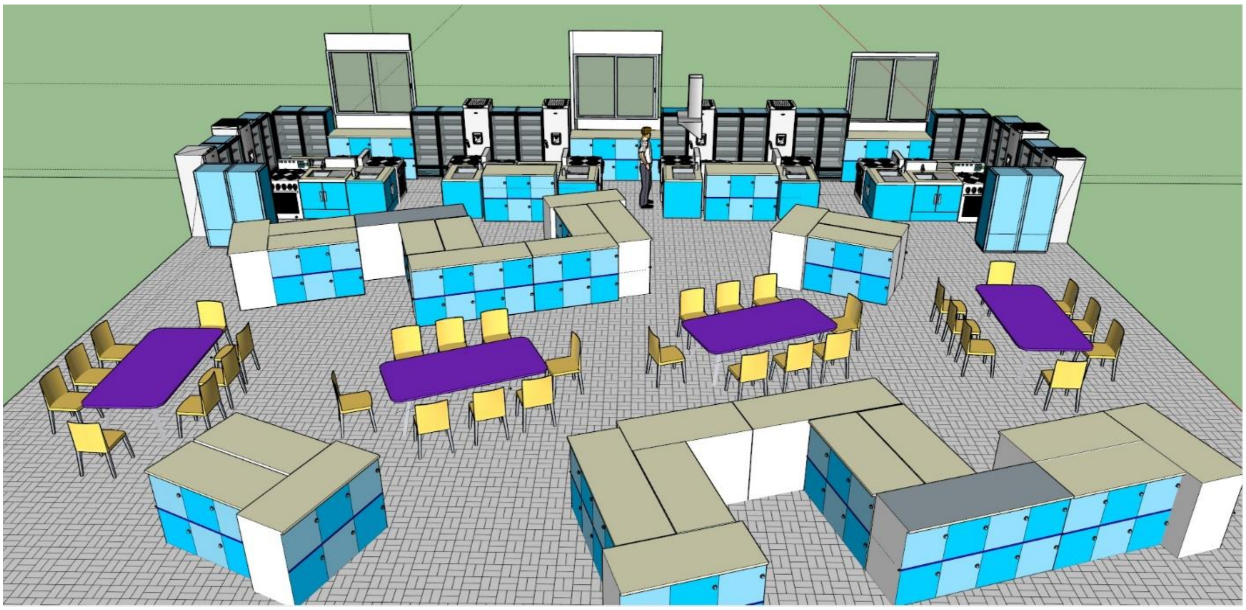

Figure 4 Sketchup Modelling

The design displays one of the four kitchen bays for the whole floor including the dining area and cupboard space of two bays. An overhead plan for the symmetrical half of one bay is included in appendix G. The open plan layout has been fully integrated across the whole system along with the colour tones of pale yellow, blue and vivid blue. The stove is just over 0.8m tall and cupboard zigzags 1.1m tall so as shown below, vision is unhindered from the man’s perspective.

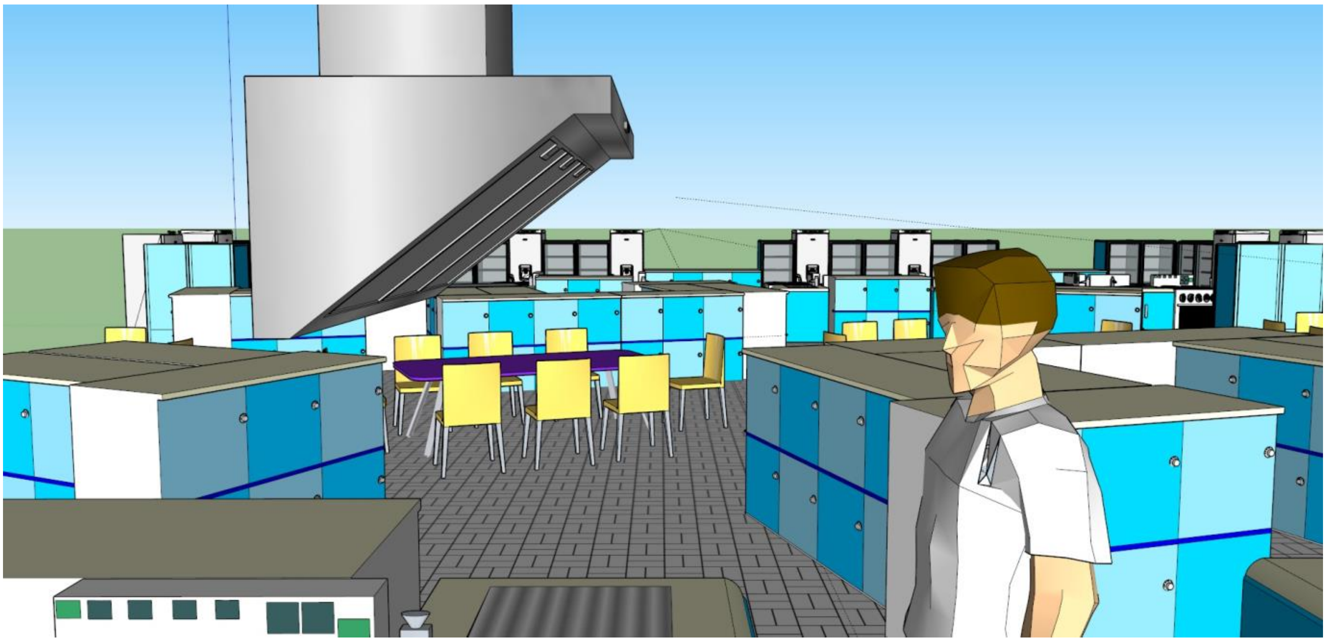

Figure 5 Open plan design

The colours along with the cupboards arrangement stimulates interest in the kitchen space to improve student experience and facilitate engagement. A 1.75m Tall man has been included to show the relative heights of components in the design and it is clear that the cupboard no longer blocks off the bay areas as in the current kitchen. Much larger windows have been incorporated and although only one exhaust hood is displayed, this is to show the intended concept as further investigation into the ceiling filter pipeline is required to fully integrate them for each stove. Note that rubbish bins have not been added as this was considered not vital to the conceptual elements of the solution and also a flexible component that could be added during later testing stages.

10.0 Verification and Evaluation

The design has demonstrated a proof of concept for the proposed solution. Evaluation of its performance is currently very limited due to the fact that there is no implementation so some requirements which have qualitative benchmarks require later stage testing. The following requirements however can be compared to the current system.

Requirements	Fridge Space	Freezer Space	Cupboard Space	Dining Space	Visible Space
Current Kitchen	68L	21L	0.135m^3/unit	192m^2	23.8m^2/bay
Proposed Design	79.3L	25L	0.15m^3/unit	~220m^2	238m^2/bay

Table 5 Comparison Evaluation

Evidently, there has been significant improvements across all requirements above and other requirements such as ventilation and colour have also been definitely improved, though evaluation from client feedback is required. The visible space is virtually the whole half of the floor due to the complete adaption of open plan layout. The kitchen work triangle distances are also satisfied unlike the current system. This along with the simpler to operate combination locking mechanism (see appendix H) should improve convenience for the student, however, these are qualitative requirements that require student feedback to validate. Relevant calculations and commercial examples with dimensions accounted for are included in the appendix I.

11.0 Life Cycle Considerations

To maximise the lifetime of the system, more efficient use of the components is possible through organised communal cooking. Cooking for each other can be enjoyable (Clear, 2013) and encourage student engagement. This would reduce the usage of appliances and extend their lifetime. The waste generated from cooking may also be lessened which would reduce emissions and utilities (gas, water, electricity) usage. This would improve the sustainability of the design in a more cost effective way than purchasing expensive appliances that have high energy ratings. Assigning students to particular kitchens may improve cleanliness by instilling a sense of responsibility for the area and possibly pride. Cleaner environments would not only improve the student attitude towards the kitchens but also result in better waste management and recycling. Overall, implementing social functions into the system can also improve the performance and lifetime while having positive consequences on environmental impact.

12.0 Further Considerations

The design has not addressed accessibility issues such as students requiring special assistance to cook. Since the proposed design has left the space for one of the half bays in the current design, a separate kitchen specific towards students who require assistance can be placed there. This issue was also considered beyond the scope of the problem and it is highly likely that existing solutions are present in Fenner Hall.

Some of the suggested appliances have high height limits. The double door fridge stands at just under 1.85m. This should be noted when assigning compartments to avoid issues with reach. There may also be an issue with the colour chosen as different cultures perceive colours slightly differently (Ou, 2003). If this solution is to be implemented, it may be beneficial to make changes to one bay for testing first to avoid large costs in changing colours.

13.0 Conclusion

The system approach taken has focused on first breaking down the kitchen system into functional and systems levels in order to find trade-offs and insights into directions for improvement. While customer requirements have been the main basis of design requirements, the additional design aim of improving student experience of using the kitchen has also been heavily incorporated. These insights were investigated further through research throughout the process to make design decisions such as for colours used, and components selected. Concept generation focused on comparing the current system to requirements and exploring ideas to improve on them with all the previous insight. Finally, an original design was proposed and evaluated at a quantitative level to demonstrate the proof of concept where possible with commercial appliances. Further testing involving students will be required to validate the design and suggestions have been made to improve the sustainability and lifetime of the system. Social concepts have also been suggested to improve the system performance. Overall, the foundation and future direction for this design has been detailed in this report and the design is successful at the current level of testing.

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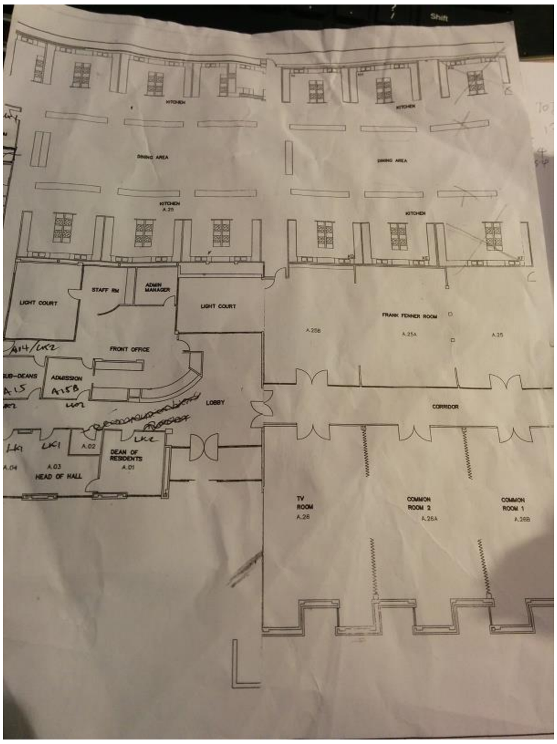
Appendix

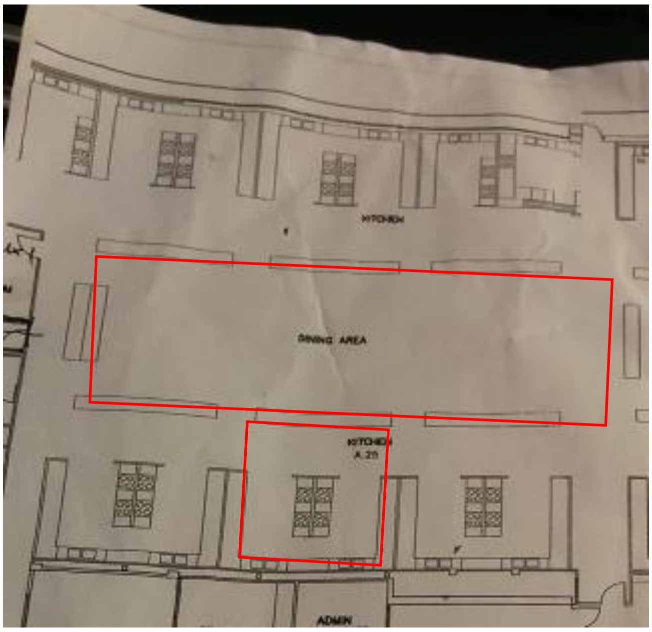
A Architecture plan of Fenner Hall Kitchen area with scale (not shown but 1:200). The kitchen area measures 19cm x 9.75cm which equates to 38m x 19.5m = 741m^2



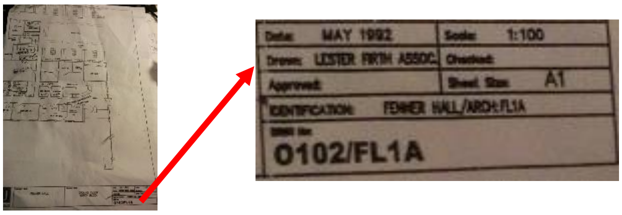
B Photos taken of current Kitchen

C Measurements for testing of kitchen. The cupboard measurements were taken to be 60cm depth, 45cm width and 50cm height. $0.6 \times 0.45 \times 0.5 = 0.135m^3$. The Fridge litres were taken through investigating the fridge in use which was a Westinghouse Frost Free 442. The specifications were found online at http://www.appliancesonline.com.au/442l-westinghouse-fridge-wtm4400wbrh/.

The measurements for the visible bay area was determined from the plan sheet in appendix A as the area within the bay since the cupboard walls blocked vision. The Dining space was the large centre area.



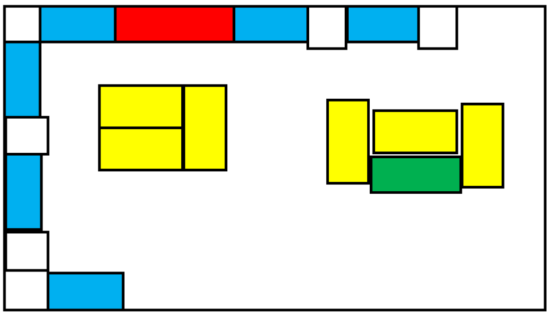
D Plan sheet



E Burton and Garret Hall fridge screen. There are also locks but may not be clearly visible for each compartment.

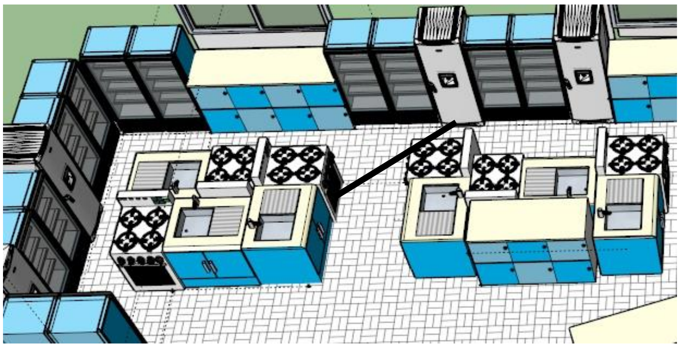
F Colombo House UNSW, 2015, Colleges, http://www.rc.unsw.edu.au/colleges/unsw-colleges

G The basic plan is shown below

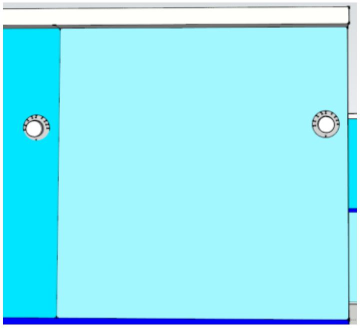


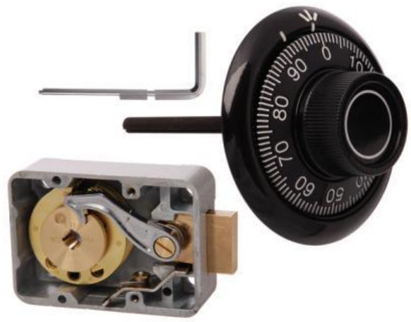
Blue indicates the fridges which are (width x depth) 1.2x0.6m. White indicates the freezers which are 0.64x0.7m. The red indicates the window cupboard space which is 2x0.6m. The green indicates the smaller cupboard space of 1.5x0.6m. The Yellow indicates the stove, sink and oven integration which are 1.4x0.7m. The same dimensions were incorporated in the sketchup model with the maximum areas restricted to the available kitchen area. The height and width of the covered area is 5.08x9.06m which is much less than the allowed. Since the kitchen area is split into two equal parts 17.6x19.6m, half of this would be 8.8x9.8m. The leftover area has been allocated to dining and the zig zag cupboard space.

H The maximum distance between 2 nearest components of the 3 sink, stove and fridge/freezer is shown by the black line which has an equivalent distance of 1.8m. Much lower than the maximum 2.7m as indicated by the triangle rule.



The locking mechanism is shown below. The left is the current key lock mechanism which requires potentially 2 hands (for the fridge padlocks) and a key. The proposed idea is based on a wheel combination lock that is also commercially available. Image from https://www.safesgalore.com.au/shop_image/product/ebb2f36cd75ff82e1c5a65a7a23e757b.jpg





I The transparent display fridge used was found from http://www.ebay.com/itm/NEW-2-FULL-DOOR-GLASS-DISPLAY-COOLER-REFRIGERATOR-28-CU-WE-SHIP-ORDER-IN-24-HOUR-/291472425032 The specifications of 28 cubic feet equate to 793L and since there are 10 differentiated compartments (5 each side) each compartment can be allocated to one student with an increased storage space of 79.3L. The important specifications of width at 125cm and length at 57cm is accounted for in the sketchup design. The freezer selected was from http://www.thegoodguys.com.au/fisher-and-paykel-389l-upright-freezer-e388lxfd which has a capacity of 389L. It was decided that since each bay served a quarter of the max capacity of 500, 125x25=3125L so 8 freezers would provide 24.9L for each student. The new cupboard dimensions were 60 depth, 50x50cm giving a total 0.15m^3 space.