

AC 2009-40: A FIRST-YEAR ENGINEERING AFFORDABLE-HOUSING PROJECT

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A First Year Engineering Affordable Housing Design Project

Abstract

A second year biomedical engineering student, instructors, agencies and members of the community worked together to design a first year engineering design curriculum for seven hundred and fifty entry level engineering students for the 2008/2009 academic year. The goals of the curriculum are threefold: to make students aware of our city's 10-year Plan to End Homelessness, to introduce a workshop on the root causes of homelessness, and to design sustainable, inclusive, affordable housing (Fig. 1).

This presentation will focus on a hands-on design project for all first-year engineering students. In 24 teams of 28 students, they will design affordable housing that is structurally sound, sustainable, cost-effective, aesthetically pleasing, functional, meets the client's needs and has community input. The 30-student team will be subdivided into 4-person groups. Each group will cover one of the following aspects: project management, urban planning, sustainability, interior design, building, costing, and architecture. Effective communication will be key to the success of each 28-person group.

As part of this project, community members will be surveyed to consider their needs for potential future affordable housing developments. The surveys will be used to identify specific concerns the community has about affordable housing projects and how these homes/buildings can be better designed to minimize those concerns. Including a community voice in the affordable housing project may help to reduce NIMBYism (Not In My Backyard).

This design project hopes to educate engineering students about the local issue of homelessness. At the same time, it will give students the opportunity to apply their skills and knowledge towards a solution to an open-ended, real-world problem. This paper will describe the project details and will have examples of student design work.



Figure 1: Example of modular affordable housing - Spacebox in The Netherlands¹

Introduction

This design project is for the courses ENGG 251/253 Design and Communication at the Schulich School of Engineering at the University of Calgary. The two courses are mandatory for first year engineers and run for two semesters. There are approximately 740 students enrolled in the course. The course is a collaboration of art, engineering and communication created in response to the challenge to innovate. The course is built around 4 pillars: *drawing, design, communication, and teamwork*.

This course runs new projects every year and has community involvement for most projects. Curriculum in the past has included Inclusive Design, Engineers Without Borders, Solar Decathlon, Biomimicry, Aids for Assisted Living and Medical Equipment Design.

Curriculum Goals

The course teaches first year students the design process via engineering concepts and principles and oral, written and visual communication. This design project is designed to educate engineering students about the issue of homelessness. At the same time, it will give students the opportunity to apply their skills and knowledge towards the solution to an open-ended, real-world problem.

Students will learn how to work in a large multidisciplinary team. They will learn how to have effective meetings, presentations, and how to communicate effectively in a large team. Cost-effective design will also be an important learning outcome. They will also learn skills and knowledge specific to their team. For example, some students will learn how to use computer software to make 3-dimensional virtual models. Students will also be more aware of an important social issue in their city.

Logistics of 740 Students

The students are divided into 6 “colours.” Each colour has lab time together. In lab time, these colours are divided into 4 lab rooms of approximately 28 students. In each lab room, there are about 4 students to a table. There is one 3-hour lab and one 1.5- hour lab every week. There is one lecture every week. Two colours attend one lecture together (Fig. 2).

There are several engineering instructors, one art instructor and one communications instructor. The art and communications instructors lecture every other week. Engineering instructors walk through the lab answering questions and give brief ‘as needed’ engineering concept lectures. In addition, engineering instructors often communicate to the students via video recordings.

Time	Monday	Tuesday	Wednesday	Thursday	Friday	
8:00		ENGG 253 B13,B14,B15,B16		ENGG 253 B17,B18,B19,B20	ENGG 253 B13,B14,B15,B16	
8:30						
9:00					ENGG 253 B17,B18,B19,B20	
9:30						
10:00						
10:30						
11:00	ENGG 253 B21,B22,B23,B24		ENGG 253 B01,B02,B03,B04		ENGG 253 B01,B02,B03,B04	
11:30		Lecture02 ENA201				
12:00		11:30am 12:30pm				
12:30		Lecture01 ENA201	ENGG 253 B21,B22,B23,B24			
13:00		12:30pm 1:30pm				
13:30						
14:00	ENGG 253 B05,B06,B07,B08	ENGG 253 B05,B06,B07,B08		Lecture03 ENA201	ENGG 253 B9,B10,B11,B12	
14:30				2:00pm 3:00pm		
15:00				ENGG 253 B9,B10,B11,B12		
15:30						
16:00						
16:30						

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Figure 2: Lab and lecture breakdown for first year engineering design with 740 students

During the course of the project a blog will be kept to show student process, progress and work. We decided on a blog format after city officials inquired how they could keep track of this project. The blog can be found at sixeightfour.blogspot.com.

Community Participation

This project was developed in discussion with several individuals in academia; researchers in the field of anthropology, urban planning, social work, and nursing were consulted. In addition, community organizations were approached, and workshops and symposia were attended. One of the larger community groups, the Calgary Homeless Foundation, had many useful suggestions for the project. The foundation will also provide guest speakers and judges for the annual Open House during the last week of classes.

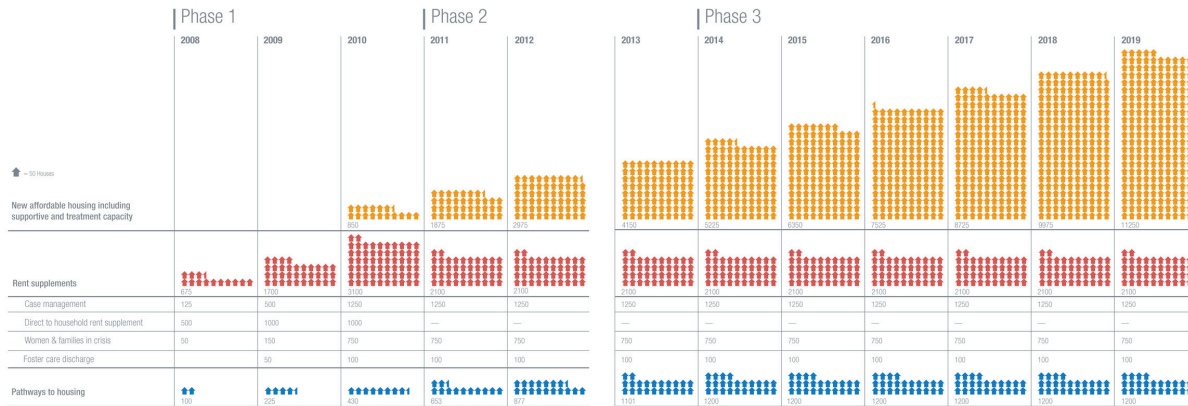


Figure 2: The city's 10-year plan to end homelessness affordable housing schedule ²

The Project

The goal of the project is to design hybrid affordable housing for homeless people and low-income families (Fig 3). This design project will run for 7 weeks. It will be the last project of winter semester. Each group of 28 students will be working on one affordable housing project prototype most likely in the shape of a module that can be tessellated into a larger structure (Fig. 4). Each lab room (group) will have at least 7 teams. Each team will work on a different aspect of the project. Together, the teams will design affordable housing that is modular, structurally sound, sustainable, cost-effective, aesthetically pleasing, functional, client-focussed and has an element of community input. It will be a modular, multi-unit building shown via a Google Sketch-up model.

Each team will report their progress and results. They will follow the designated design process: Familiarization, Functionality, Testing with the Inclusive Design Process . Each classroom (group) will deliver a poster outlining their design, a virtual visualization of the building and a prototype that is one of the units of the building.

The students will pick three out of a 'ten client' list, based on which they will chose the site of the building. Once the community and the clients have been picked, the larger team will then decide what design considerations are important.



Figure 3: An example of affordable housing using shipping containers ³

Project and Prejudice

A special workshop was designed based on an Engineers Without Borders workshop, Root Causes of Poverty. The new workshop is titled: Root Causes of Homelessness in Canada: A Consciousness-building Workshop. The purpose of this workshop is to discuss homelessness with novices to the issue and challenge any prejudices that might exist. The structure of the workshop allows participants to make up their own minds on various aspects of the issue, interact with other participants, and engage in critical thinking.

It has three parts: a directed map of causes and effects, a discussion in small groups, and a debate involving all participants. The workshop will take on the following format:

i. Part I: Mapping Causes and Effects

In groups of four, participants will read through the provided client story. They will then write down several causes and effects of homelessness, drawing arrows from the causes to the effects. Next, they will discuss their client's story and their directed map with all participants. The workshop facilitator will discuss the causes of homelessness with the participants.

ii. Part II: Group Discussion

In the same group of four, participants will discuss the following questions:

2. Of the causes, which ones are risk factors for homelessness? Which can directly trigger homelessness?
3. Comment on any patterns you see on the chart.
4. There are several reasons to help homeless people: moral obligation, social well-being, economic benefit, etc. What is yours?

i. Part III: Debate

The workshop facilitator will divide the groups into 'for a statement' and 'questioning a statement'. The two groups will first discuss how much responsibility a person has in becoming homeless. Then they will debate the assigned statement.

Example Statements:

"Sobriety should be a requirement for social housing."

"Homeless people should not qualify for social assistance."

"Society has a responsibility towards homeless people."

The workshop will be conducted in groups of around 30 participants (all the students in the lab room). Participants are given some information at first. Then they are given progressively more chance to form an informed opinion about various aspects of the issue, all the while taking other people's opinions into consideration.

Project Team Breakdown

Each team is responsible for a specific aspect of the project. The deliverables for each team vary according to their area of interest. There is significant overlap among several teams. It is, therefore, possible to negotiate any unintended workload imbalances. The project was in week one when this paper was submitted. Included below in quotation marks are some of the blog entries from the first stages of research.

ii. Project Management Team

The Project Management Team is responsible for keeping the project on track with regards to the budget and deadlines. It is also responsible for organizing meetings and facilitating team cooperation. This team will learn several project management tools. It also has to be knowledgeable of every team's design decisions and justification. It can also share the workload of overburdened teams. In addition, this team is responsible for putting together the display and presenting the group's project at the Open House.

“ Once there are three different concepts, costing and sustainability will work closely with these groups and lead them to one idea based on all the pros and cons.”

“Some anticipated roadblocks in the near future include but are not limited to upcoming midterm examinations.”

“At the moment all groups are on schedule and there has been excellent communication between teams. Each team is also making certain that the labour is being divided equally. Some resources that the teams have been utilizing include: Google Earth, the City of Calgary webpage and www.treehugger.com. Groups are also phoning contractors, realtors and city to further their research.”

“Project management has set out deadlines for every major developmental step on the project to ensure that groups stay on track and ideas are constantly integrated as the project progresses. As of March 13, all groups are on target for timely completion of the project.”

“The lab also chose its target client as families, single women and students. This decision was made as a lab by vote. These clients were chosen to present a realistic challenge and also address a major need in the homeless community. Families need a strong home environment and our lab felt this was something that could be addressed in conjunction with the needs of single women and students.”

“A lab-wide Gmail account has also been created to send all communications to and make use of Google calendar to schedule deadlines.”

iii. Urban Planning Team

The Urban Planning Team is responsible for consulting the community and getting input regarding the design of the building and the integration of affordable housing into the

community. The team also has to research and be mindful of land use laws. The team will learn how to conduct surveys and consult clients about design issues. In addition, they will develop concepts that address the requirements developed from the consultations.

“ We are looking to create a vibrant, walkable community, whether we build in an already developed or developing area.”

“ The main task for the Urban Planning team now is to weigh the pros and cons of these two properties and pick the one that would allow the proper zoning laws as well as giving the people access to community recreation centers and schools.”

“This structure is intended to provide a service for people in need of low-income housing, and important considerations in the location of the structure are the services that are available in the surrounding area.”

“Our criteria can be summarized as follows:

- Proximity to Basic necessities like grocery stores, pharmacies, etc.
- Easy access to public transportation (word chosen was Accessibility).
- Near Post-Secondary Education.
- Existing poverty/crime rates in the neighbourhood should be relatively low, as in below 26%.
- The neighbourhood should have pre-existing medium/high density housing to avoid NIMBYism and to help integrate the building into the location.”

iv. Sustainability Team

The Sustainability Team will try to incorporate sustainable practices into the design of the building. They will incorporate energy-efficient appliances and fixtures into the design. In addition, they will also calculate the cost of heating, electricity and water in the building. They will also incorporate environmentally friendly materials into the design of the building. This team will be able to carry over many ideas from the Solar Decathlon project that was done in the Fall of 2008.

“Familiarization and research current sustainable, environmentally friendly building practices
Compile list of relevant options: Solar, grey water, lighting, building materials, heat recovery, landscaping”

“The Sustainability group has reported that they selected a keyword – harmony. They have decided on using the concept of xeriscaping for green spaces by introducing only local plants.”

“We came up with the idea of a rooftop greenhouse.”

v. Interior Design Team

The Interior Team will design the interior of each unit. Since each unit will be small to cut down on cost, they will design and incorporate space-saving, multi-functional, and possibly structurally-integrated furniture to serve the needs of the occupant. Layout considerations will also be a part of their design. They will produce a visualization of the interior of the unit (Fig 5). Depending on the units they are designing, kitchens may be optional in case of a communal cooking facility.

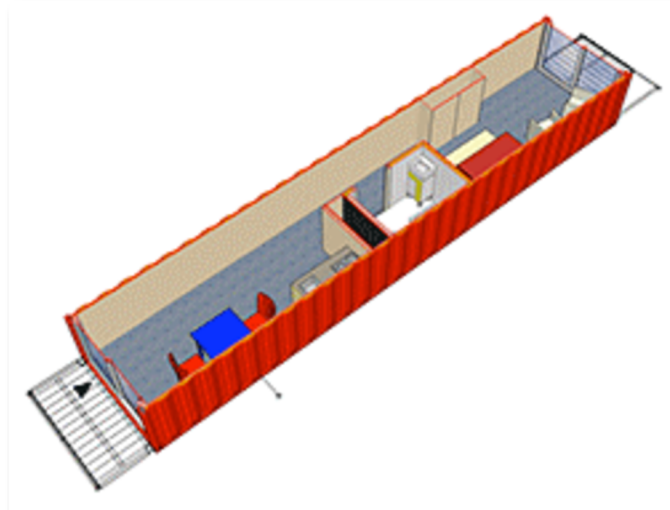


Figure 4: The layout of the 'professor' container from the Keetwonen project ⁴

“ The interior design team's goals this week are versatility, incorporating space saving, and working on teamwork.”

“The Interior Design group has started doing research on RVs and boats to gain ideas about efficient living in small spaces and multi-functional furniture. They are also considering using the concept of Feng Shui for incorporating arch walls, colors and their impact on the moods of people living there.”

“Our design aims to meet the needs of a variety of people in a variety of different building configurations.”

“There will be a focus of flow in the apartment; seamlessly transitioning from room to room.”

“The interior design team has begun discussing ideas of how to maximize the use of each unit’s limited area. These ideas include multifunction rooms and rooms that are easily convertible to meet a variety of needs. Some ideas of how to achieve this have been to create more universal designs (that can suit the needs of all our clients) and through the use of movable partitions within each unit.”

“This week we divided the research and designing among the team members based on the different clients that we are designing for. For example, one team member researched the specific needs of single men, one team member researched the specific needs of youths, and one team member researched the specific needs of students. A different potential interior was then designed for each client based on their specific needs.”

vi. Civil Team

The Civil Team is responsible for selecting the construction materials in conjunction with the Green Team, and designing the structure of the building (Fig 6). They will also consider insulation in their design. Several engineering analyses methods will be used. They will also have to test the validity of their analysis and justify their design decisions.

“Stability and Structure: These words signify both the physical and social aspects of the affordable housing project. The physical aspect involved would be the building itself. Being the civil engineering group, we have to ensure the structure of the affordable house is stable. As for the social aspect, homelessness is a crucial issue in our society. By building this affordable home, we provide stability to the community.”

“The group will also focus on collaboration with the architectural team in order to finalize the decisions on materials. Then testing will be performed to make sure the material choices are safe, and are able to withstand different loads and environmental stresses.”

“Cellulose fibre insulation appears to be the best material in terms of sustainability; however, costing is still evaluating the feasibility of this material.”



Figure 5: Construction of Spacebox ⁵

vii. Costing Team

The Costing Team will try to incorporate cost-effective practices into the design of the building in order to minimize the construction cost of the project. They will also try to approximate the running costs of the building and ways to offset it. Ultimately, they will come up with an approximate cost of the building.

“Costing has also been busy this week determining the approximate costs for the plots of land being considered by urban planning, materials from civil and outer shells from architecture.”

“Work Completed: Preliminary research, calculate approximate budget, pie chart of budget, prepare presentation, rent calculations and total cost for 25 units

Work To Be Completed: Moral support, more accurate estimates after evaluation of necessary costs and interim report.”

viii. Architecture Team

The Architecture Team will design the exterior of the building. They will also incorporate value-added space to the building such as ground-level stores, a learning space or shared laundry facilities. They will also consider landscaping and the aesthetics of the exterior. In addition, they will produce a visualization of the exterior of the unit. Figure 7 shows a detail of Container City, an apartment and studio structure in London.



Figure 6: Container City Architecture⁶

“ Our goal is to design a building that blends into the community chosen by the urban planning group. We also hope to design a building that promotes community within itself. That is to say that we want to design our building to help the people living there to create friendships with those around them.”

“ The main problem that the team was encountering is that it hard to design the outside layout according to the restrictions being put in place by local zoning laws.”

“To design a functional yet visually pleasing structure that will be structurally sound but that will also synergize with the neighbourhood.”

Project Timeline

The project timeline can be seen in Table 1. Each week, there will be 50 minutes of lecture time and 4.5 hours of lab time. In lectures prior to the start of this project, students were introduced to the history of design and design styles from 1850 to present. The year 1850 was seen as a good starting point since that is when engineering as a profession started to influence design, architecture and materials. Students were also given multiple existing examples of current sustainable, affordable housing projects such as Spacebox and Keetwonen in The Netherlands and Container City in the U.K.

At the end of each week, students will have deliverables as a way to keep them on track and on time. In the first week, the lecture will introduce homelessness, Calgary’s 10 year plan to end homelessness, and the project. The ‘Root Causes’ workshop will be conducted in the first 1.5 hours of the lab, followed by a workshop introducing the harsh economic realities of living on social assistance or “welfare.” Next, they will have some time to conduct research.

In the second week, students, with the help of their project management team, will write a team contract in their group of 28 students. The 'lab' contract will detail the academic commitments of each student and the consequences should a student slack off. This 'lab' contract is on top of a team contract among a team of four students. Two guest speakers were invited to share their story with the students. Our local EMT-P Superintendent of Special Operations gave an overview of a new strategy recently adopted in Calgary:

The City of Calgary has experienced unprecedented growth in the past few years. The Centre City faces a multitude of challenges that include increased traffic congestion, economic growth, community sprawl and an increasing diversity of the populace. The demand on EMS resources has grown at an average rate of 9% over the last six years. Significant demand on resources is from an increasing number of vulnerable individuals (the homeless, addicted, and mentally ill) living in the Centre City who have limited access to basic health services and have a high rate of recidivism.

EMS has created a specialty team devoted to the Centre City. This specialty team is comprised of 20 paramedics who have an understanding, training and interest in vulnerable populations and the issues associated with the inner city (e.g. addictions, homelessness and mental illness).

The team has established links with social agencies and programs to ensure vulnerable populations receive the right care. It has created an alternate response strategy reducing the convergence of emergency response vehicles in the core. Also the increased "EMS presence" contributes to citizen confidence that Calgary is a safe and vibrant place to live.

Another guest speaker associated with the Calgary Homeless Foundation talked about the economic consequences of homelessness. In the lab time, students will have time to get themselves oriented with the project, and do some research.

The next few lectures will introduce several topics useful to their design. They will report their progress by means of an oral presentation and a written report. In lab time, they will familiarize themselves with affordable housing issues and information specific to their team. Next, they will develop some concepts and test them. Their final deliverable will include a prototype of a module of the building, a Google Sketchup visualization, and a poster, handed in as a group. The final report is specific to each 4-person team. The Open House will feature the 24 projects with their prototype, poster and visualization on display. Members of the Calgary Homeless Foundation will judge the projects and hand out prizes.

Table 1: Proposed Project Timeline

Week	Deliverables	Lecture	Time (hr.)	Lab	Time (hr.)
1	Logbook Reflection	Homelessness Facts	0.5	Root Causes Workshop	1.5
	Research Questions	10 Year Plan	0.25	Welfare Workshop	0.5
		Project Introduction	0.25	Homelessness Research	1
				Affordable Housing Research	1.5
2	Lab Contract	Guest Speaker	1	Project Introduction	0.5
				Team Description & Choice	0.5

				Lab Contract	1
				Pick Clients	0.5
				Affordable Housing Research	1.5
				Affordable Housing Speaker	0.5
3	Oral Presentation	Modular Housing Types	1	Group Familiarization	2.5
				Develop Requirements	0.5
				Oral Presentations	1.5
4		NIMBYism, Urban Planning	1	Develop Concepts	2
		Civil, Architecture		Do Specific Research	2
				Test	2
5	Progress Report	Testing Methods	0.5	Conduct Head Meetings	-
		Progress Report	0.5	Write Progress Report	3
				Starting Building	
6				Build Prototype	4.5
				Make Poster	
				Make Visualization	
7	Prototype	Project Results		Open House	3
	Poster	Survey		Final Report	-
	Visualization			Final Clean up	1.5
	Final Report				

Community Survey

The community survey will be conducted by students in their own community. They will ask their families and neighbours of their opinions of affordable housing. The purpose of the survey is to discover if the design of affordable housing can mitigate some of the concerns raised by the community (Fig. 8).

The survey shown in Figure 8 was designed for a downtown community that is trying to understand the impact of affordable housing on their community. The survey starts by debunking homelessness myths: “In communities throughout North America, studies have shown again and again that well designed, well-built and well-maintained affordable or non-market housing has little or no effect on neighbourhood property values”. It also discusses financial burden of temporary housing on the city: “But we’ve also begun to realize that homelessness is exacting a terrible economic toll. Our own analysis shows it costs taxpayers more to manage homelessness than it would to end it”. It also gives examples of successful projects that have been built in North America in recent years.

We will have statistical data at the time of the paper presentation. Over 400 individuals will have responded to the survey at that time.

Outcome: Student Survey, Projects and Examples

Examples of projects will be included and will be available early April. A survey will be conducted to measure student learning, success and satisfaction with the project. Student have finished part one of the survey and will be surveyed once again at the completion of the project. The results of this survey will be shared during the conference presentation.

Conclusion

This course teaches first year students the design process via engineering concepts and principles and oral, written and visual communication. All design projects are created to educate engineering students about real world engineering problems, in this case: the issue of homelessness. We hope students learn to appreciate to complexity of design problems and working in a 28-person group. They should come out of this semester with a good understanding of project management and a more empathetic view of homelessness in our city. Ultimately, we hope to inspire the organizers of the 10-year plan (Fig. 9) to end homelessness by having all 740 engineering students work on this issue.







Downtown West Community Survey Questions:		Source:
1. What are some of your concerns regarding affordable housing (ex: increase in crime, traffic, etc.)?	development to be like (ex: stand out or blend in the community)?	
2. What features would you like to see in a potential affordable housing development	4. What would you need to see in order to be comfortable with an affordable housing development?	
3. What would you like the design of a potential affordable housing		
5. Which of these designs of affordable housing would you prefer in your neighborhood? Circle the letter of your choice.		
A. Space Boxes, Netherlands and/or Habitat 67, Montreal	 	
B. New Carver Apartments, L.A. and/or Lore Krill Housing Co-operative, Vancouver	 	
C. Schermerhorn House, Brooklyn and/or Schiff Residences, Chicago	 	

Figure 7: Page from community survey designed for the project



Figure 8: Meath Gardens Converted Containers ⁷

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